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PORTFOLIO ANALYSIS FOR SELECTED HONG KONG SECURITIES

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ABSTRACT

This paper attempts to study a newly developed technique in portfolio investment, called Modern Portfolio Theory, and to apply it in the local securities market. This is carried out with the major aims of quantifying the risk involved in investment and constructing the best portfolio for an investor. A number of securities were selected for study from the local securities market and analysed with the aid of computers and the Quadratic Programming technique. A simplified model, called the Sharpe's Single-Index Model, was constructed and utilised in the analysis.

FOREWORD

I wish to take this opportunity to express my gratitude to a number of persons for their generous help and guidance in the accomplishment of this thesis.

My most sincere thanks are due to Mr. Jerome J. Day, Jr., my thesis supervisor, for his constant help and advice, without which the research would not have been possible. Not only did Mr. Day give me ample research guidelines and advice, he also gave me encouragement in the course of my research and insight into Portfolio Theory.

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I also want to take this opportunity to express my gratitude to a number of local firms who cooperated wholeheartedly during my lengthy interviews and supplied me with invaluable information. They are the Hang Seng Bank, Ltd., Jardine Fleming Investment Company,

FOREWORD (Continued)

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Finally, I wish to thank several friends of mine for their help : Mrs. Barbara Carmone, for editing and correcting my drafted thesis; Mr. Kimun Lee, for his general comments and guidance; friends at the Computer Services Terminal, for their valuable contributions of time and effort in making my computer runs; and several very good friends for helping me type and proof-read the thesis.

20th May, 1974 LAM Soon-kong, Alex.

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CHAPTER 1

INTRODUCTION

1.1 HISTORICAL DEVELOPMENT OF PORTFOLIO THEORY

With increasing pressure for higher rates of returns and with advances in performance measurement techniques, portfolio management's activities have evolved in recent years, reaching a critical and innovative phase. The historical setting reflects the inability of investment analysts to express quantitatively their views concerning risk and its relationship to investment return. This lack of a quantitative risk dimension created widespread confusion as to the measurement of portfolio performance and portfolio decision-making procedures.

Interestingly enough, the first literature on the measurement of risk started as early as 1730 when Bernoulli published his "Exposition of a New Theory on the Measurement of Risk." But Bernoulli's work had little effect on the fields of finance and economics. In 1952, Harry Markowitz suggested a simple, yet powerful, approach for dealing with risk. Since then, there has been a veritable revolution in the field of finance, especially in the field of investment. William F. Sharpe was among those who succeeded at exploring the area in depth. The result was a significant body of new thought concerning the usefulness of widely employed investment decision-making practices - a body of thought now described under the general heading of "Modern Portfolio

Theory" or "Capital Asset Pricing Theory," the basic elements of which emanate from the series of propositions concerning rational investors' behaviour set forth by Markowitz.

Modern Portfolio Theory treats risk in quantitative terms for the first time. The first assumption of the Theory is that the investor will act according to the Principle of Risk Aversion and will desire to achieve the portfolio that maximizes return for any given level of risk through effective diversification. It focuses on the problem of overall portfolio composition and performance rather than treating the investment by traditional exhaustive analysis and evaluation of individual security issues. The Theory asserts that it determines the "best" portfolio for the investor among the set of portfolios composed of all the possible combinations of the constituent stocks.

These techniques and theories have been slow to evolve and to gain acceptance by the investment circle. Nevertheless Modern Portfolio Theory has already gained some ground in the United States securities market and investment circle.[1] Evidence has shown that there is increasing interest in and application of Modern Portfolio Theory in real practice elsewhere. As a matter of fact, some of the regulatory or professional bodies have already started to advocate the use of

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[1]A survey /1, p. 792/ had been carried out by Shearson, Hammill and Co., Inc., a brokerage firm, on the application of Portfolio Theory for sixty institutional investment organisations in the United States. The result showed that about one-third of the organisations are actively involved in the application of modern investment theory to their daily practices. Another third have made a start, and only one-third are still "just thinking about it."

quantitative risk dimension as a yardstick[1].

1.2 GLOBAL PICTURE OF PORTFOLIO INVESTMENT

Stage I : Security Analysis

1. Initial screening (by EPS, PER, NAPS, criterion of investor, etc.)
2. Projection of required estimates, i.e. r_j, σ_j^2, σ_{ij}, etc.

↓

Stage II : Portfolio Analysis

Determination of efficient frontier by Markowitz diversification

↓

Stage III : Portfolio Selection

Determination of the efficient portfolio, given the risk level of the investor

↓

Stage IV : Portfolio Revision

With new information, and as the portfolio becomes less than efficient, the portfolio is revised to achieve optimality

EXHIBIT 1-1 : Global Picture of Portfolio Investment

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[1] These included the Securities and Exchange Commission (SEC) and the Bank Administration Institute (BAI). For reference, see "Measuring the Investment Performance of Pension Funds," Park Ridge, Ill., pp. 15-16 by the BAI and "Institutional Investor Study Report" (Washington, D.C. : U.S. Government Printing Office, 1971), Part: Vol. II, pp. 263-65, 400-10 by the SEC.

Modern Portfolio Theory regards portfolio investment as being composed of several stages, namely Security Analysis, Portfolio Analysis, Portfolio Selection and Portfolio Revision (Exhibit 1-1). Stage I, Security Analysis, deals with, first of all, the screening of all the securities on the stock market. In brief, it enables the portfolio analyst to focus on only those securities which have satisfied certain criteria of the investor. The security analyst may choose to select securities according to the earnings per share (EPS), dividend per share (DPS), price earning ratio (PER), net asset value per share (NAPS) or any other criterion of selection. Having made a list of securities which satisfy the requirements, the security analyst must also provide predictions about the future prospects of the securities. These are in the form of the rates of return of individual securities. The predictions must take into account their uncertainty and interrelationships too. All these predictions are used in Stage II.

Essentially, Portfolio Analysis produces predictions about various possible portfolios. It determines a portfolio's future return and risk possibilities, derived from the predictions about securities produced in Stage I. Here is where Markowitz diversification comes into play. Through such diversification, portfolios are constructed so as to be risk averse and to maximize return at any risk level. The set of all such "efficient" portfolios - portfolios which are deemed worthy of further consideration - is thus constructed and is available for the next stage.

Having determined the set of all efficient portfolios, the investor can select his own portfolio from the set to satisfy his objectives of investment. This is Stage III : Portfolio Selection. Assume that the investor has set a certain level to be his maximum level of accepting risk. With this, he can select the portfolio that best satisfies his requirements. The portfolio gives the fractions of his funds to be invested in each of the securities. Under the assumptions of Portfolio Theory, this portfolio will yield maximum return at the level of risk specified by the investor where the risk has been kept minimal by diversification of the investment.

Stage IV is concerned with Portfolio Revision. After investing in the selected portfolio for some time, the portfolio may become less than efficient because of the fluctuations of the market. It is the job of the portfolio analyst to review constantly and revise his portfolio, if necessary, in view of new information obtained or changes in the market. Essentially this is to compare the performance or predictions of the portfolio with that of the new set of efficient portfolios derived in Stage II. If it is found to be necessary, the selected portfolio will be revised so as to fulfil the investor's objectives better.

1.3 THE HONG KONG SECURITIES MARKET AND PORTFOLIO ANALYSIS[1]

Before 1969 the Hong Kong Securities Market was relatively

[1]The information presented in this section was obtained mainly through personal interviews with investment analysts and brokers in Hong Kong.

small and immature as compared with foreign markets. There were only about thirty stocks traded on the Hong Kong Stock Exchange which was then the only stock exchange. Turnover was small, and there were few investors and brokers around. The market was comparatively unknown to foreign investors. However, after 1969, there was a gradual increase in its recognition, especially towards the end of 1972. At that time, the stock market began to pick up momentum. The Hang Seng Index, the most familiar and popular index used in Hong Kong, increased rapidly from about 400 in mid-1972 and peaked at 1774 in March 1973. Turnover averaged HK$500 million per day. The number of stock exchanges had increased to four. They were the Hong Kong Stock Exchange, the Far East Exchange, the Kam Ngan Stock Exchange and the Kowloon Stock Exchange. The number of brokers had increased to over one thousand. Then, after the frenzied peak in March, the market began to collapse and crash. As of the time of our research, the stock market had not yet recovered, with the Hang Seng Index standing at about 320. Nevertheless, the Hong Kong Stock Market has learnt a lot from the bitter and costly lesson and has become more mature and sophisticated in terms of international standards.

There are relatively few outlets for investment in the Hong Kong Securities Market. Almost all the tradings are concerned with common stocks. There are about 300 common stocks. A small number of preferred stocks are traded on the stock exchanges but turnover is very small. As for the bond market, there are a few corporate bonds or debentures, all of which were floated within the last two years.

Again their tradings have been relatively limited. The Government had once issued a government debenture just after the Second World War. Thus any institutional investors making portfolio investment in Hong Kong are almost entirely concerned with common stocks.

There were hardly any systematic ways of selecting or evaluating securities for investment in Hong Kong. Not only were investors unaware of any analytical techniques, the average broker, too, was equally unaware. Most investments, then, were made on subjective criteria : from experience, word-of-mouth information, or speculative predictions. This type of phenommenon was particularly true before the collapse of the stock market. After the collapse, increasing interest was paid to the fundamentals of the stocks, usage of charts and other analytical tools. However, the risk of investment has largely been assumed without worrying much about it. No quantitative way of treating risk of investment was undertaken. Such ideas as "quantifying risk" or such terms as "Beta Coefficients" were almost unheard of, even among those in the investment circle.

Portfolios containing more than one security are constructed almost entirely arbitrarily. The general practice is to combine securities according to the will of the investor. If he chooses to invest one-tenth of his fund in each of the ten securities he has selected, he often has no idea why he chooses the figure "one-tenth"; nor does he consider the fact that another portfolio with different combinations of the ten securities might perform better than his portfolio. One institutional investor the author has interviewed is slightly better than the average. He made a study of all the industries and chose the ones he considered to be the more lucrative. He then assigned the largest proportion of his funds to the industry considered to be the most profitable, the second largest proportion to the second most profitable industry and so on. After that investments were made for selected stocks in each industry according to the funds available for the industry. Nevertheless, he still did not know whether his portfolio was the best or not. Furthermore, the risk of the portfolio was entirely unknown. There was no way to compare among various portfolios, their performance and the risk involved. Modern Portfolio Theory is almost unknown to the investment circle in Hong Kong.

1.4 OBJECTIVES, SCOPE AND METHODOLOGY OF THE STUDY

1.4.1 Objectives

The author does not want to over-emphasize the importance and the increasing trend of quantifying the risk of any investment. However, because of the rigour of such an approach in investment appraisals, and in view of the confusion arising in investment decisions as a result of treating risk qualitatively, the author was prompted to investigate and study the application of the newly developed Portfolio Theory on the Hong Kong Securities Market. Not only did the study give the author an insight into the rigour and beauty of the Theory and its applications, it also served other purposes. It caused the author to conduct a thorough study of the local stock market, its structure, organisation, regulations, characteristics and defects. It gave the author a chance to learn how investments are made in practice, and how theories can actually be put into practice. The study also allowed the author to make extensive use of computers in investment evaluations, selections and other purposes. Lastly the study made use of the mathematical knowledge that the author has acquired in his undergraduate study and applies it to the abstract mathematical part of the theory.

1.4.2 Scope

Because of the large scope of the area covered by the Theory, the author has chosen to limit his study somewhat. Therefore he could not deal with each study area as comprehensively and as deeply as he would like to. Only a part of the whole portfolio investment process is studied in great depth, namely Stage II, the Portfolio Analysis stage. For Stage I, that is, the Security Analysis stage, the risk of individual securities has been dealt with in some depth. Stage III has been touched upon slightly. The study stopped at Stage III. Since Stage IV, the Portfolio Revision stage, involves considerably more theoretical background, the author has left it unexplored.

For study purposes, the author has selected a sample of only twenty stocks for analysis, limiting the analysis to a period of six years. However, even with such limitations, the author thinks that the study has fulfilled its objectives.

1.4.3 Methodology

The first step of the study involved library research to acquire the prerequisite theoretical background and knowledge. The theory involved is so new that the author deems it appropriate to include in some detail the theoretical background in the thesis so that the reader can better grasp the material presented.

The next step involved the aid of computers. Without the use of computers, the study would have been impossible to carry out. In certain stages of Portfolio Analysis, computational procedures become very tedious, time-consuming and repetitive. The computer easily solves the computational difficulties. The author developed three computer programs for the study.

Having developed the programs required, the actual study commenced with the collection of the required data. Most of the data were collected from the Hong Kong Stock Exchange. At the same time, several personal interviews were held with experts in the field of investment, so as to get first-hand knowledge about the behaviour, practice and characteristics of the local stock market.

The most interesting part of the study constitutes the next step : the analysis of the data and interpretation of the results. Most of the results were in the form of graphs and tables produced by the computer programs.

In the final part, the author was able to give some comments on the technique employed, its limitations, modifications and applicability, and to draw a conclusion on the study.

1.4.4 Layout of the Thesis

Chapter One gives a brief introduction of Modern Portfolio Theory and the Study. The theoretical background necessary for the study is presented in the next chapter. Chapter Three presents the model constructed for the study. The actual application of the theory is shown in Chapter Four. The final chapter presents the conclusion of the study.

CHAPTER 2

THEORETICAL BACKGROUND

Portfolio Theory deals with the problem of overall portfolio performance and composition. It gives an investor a yardstick for measuring the performance of his portfolio in terms of, and only in terms of, the portfolio's return and risk. The Theory concerns itself with the concept of "Efficient Portfolio" which is obtained through the solution of an optimization problem. In this chapter the theoretical background is presented.

2.1 ASSUMPTIONS OF PORTFOLIO THEORY

How does an investor choose among alternative portfolios? The following rules [6, ch. 1] are assumed to apply for any investors. These assumptions are maintained throughout the discussion in the thesis. Investors described by these assumptions are said to prefer "Markowitz efficient portfolios" [16].

1. Investors' risk estimates are proportional to the variability of the expected returns. In other words, risk of any security is given solely by the variance of rate of return of the security.
2. Investors are willing to base their decisions solely in terms of expected return and risk. That is, Utility (U)

is a function of the variability of return (σ^2), and expected return ($E(r)$). Symbolically, $U = f(\sigma^2, E(r))$.

3. Investors are "risk averse" in that they will prefer smaller risk at the same level of rate of return. Symbolically, $\partial U/\partial\sigma^2 < 0$.
4. Conversely, for any given level of risk, investors prefer higher returns to lower returns. Symbolically, $\partial U/\partial E(r) > 0$.
5. Investors have similar "investment horizons"; that is, they view the risk-return relationship for individual securities over similar time periods.
6. Investors seek to optimize their portfolios through efficient diversification.
7. Investors have "homogeneous expectations"; that is, they hold similar views as to the variance, risk or distribution of future returns.
8. Securities are assumed to be perfectly "divisible" (that is, an investor can invest whatever amount of funds he wishes in any securities); and the investor is able to commit any desired amount of funds without affecting the price or the rate of return associated with each investment.
9. Taxes and transaction costs are ignored.

While some of these assumptions are in varying degrees unrealistic, at the current time, the theoretical development of Portfolio Theory is not sufficiently advanced to enable the assumptions to be relaxed.

2.2 THE PORTFOLIO THEORY

Modern Portfolio Theory is concerned mainly with Portfolio Analysis. Hence the thesis will concentrate mainly on Portfolio Analysis while paying some attention to Security Analysis, Portfolio Selection and Portfolio Revision.

As already discussed earlier, Portfolio Analysis follows the stage where the security analyst has finished the task of providing relevant in-formation about each individual security. Thus for any N-securities Portfolio Analysis problem, the security analyst must provide the portfolio analyst with N expected returns, N variances (or standard deviations) and the covariances of all of the securities with each other. These statistical inputs are then analysed to determine the efficient portfolio. These inputs can be obtained either from historical data or from subjective estimations by the security analyst. If the historical data are accurate, and conditions in the future are expected to resemble those from the period in which the data were derived, the historical data may be the best estimates of the future; but if the security analyst is "expert" or the market is changing, subjective estimations may be preferable to historical data.

2.2.1 Expected Return of a Security

Return on an investment is defined as any measure of performance of the investment over time. Each investor may define return in the light of his particular status and objectives. Portfolio Theory assumes that the expected return on an investment is given by the expected value of a probability distribution of return of the investment. Continuous probability distributions of return are not used; the estimated return will assume only finite values (discrete probability distribution). Thus the expected return on the ith security is defined as

$$E_i = E(r_i) = \sum_{t=1}^{m} P_{it} \cdot r_{it} \qquad (2\text{-}1)$$

where r_{it} is the t th return on investment of the ith security;

P_i is the discrete probability of r_i, and

m is the total number of all possible values of r_i.

2.2.2. Risk of a Security

Risk of a security is generally defined as the dispersion on the security's rate of return around its expected return. The Theory assumes that risk is proportional to the variability of the expected returns. Thus risk is given, statistically, by the variance or the standard deviation of the rate of return on the investment. That is

$$\sigma_i^2 = \text{var}\ (r_i) = \sum_{t=1}^{m} P_{it} \cdot (r_{it} - E_i)^2 \qquad (2\text{-}2)$$

These two measures, and only these two, are used to state the prospects for each of the portfolio's N securities. These numbers are assumed to summarize a probability distribution for the security's rate of return.

2.2.3 Interrelationships of the N Securities

One of the major attributes of Portfolio Theory is its insistence that interrelationships of various securities be taken into account. The relationship among the rates of return of the securities may be stated in terms of covariance or correlation coefficient of the rate of return of the securities. Quantitatively, the covariance between two rates of return is the weighted average of the products of the unnormalized deviation, with their joint probability as weights.

$$\sigma_{ij} = \sum_{t=1}^{m} P_t(ij).(r_{it} - E_i).(r_{jt} - E_j) \qquad (2\text{-}3)$$

The correlation coefficient between the two securities is given by :

$$R_{ij} = \frac{\sigma_{ij}}{\sigma_i . \sigma_j} \qquad (2\text{-}4)$$

The value of the correlation coefficient is between $\pm$ 1.

2.2.4. Expected Return of a Portfolio

A portfolio's expected return is the weighted average of the expected returns of its component securities, using the proportions invested, X_i's, as weights.

$$E_p = \sum_{i=1}^{N} X_i.E_i = \sum_{i=1}^{N} X_i.(\sum_{t=1}^{m} P_{it}.r_{it}) \qquad (2\text{-}5)$$

Note that $X_i (1 \geq X_i \geq 0)$ is equal to zero when security i is not included in the portfolio.

2.2.5 Risk of a Portfolio

Following the same line of defining risk for a security, a portfolio's risk is defined as the variability of its return and is given by the variance or standard deviation of the portfolio's return. Symbolically,

$$\sigma_p^2 = \sum_{i=1}^{N} X_i^2 .\mathrm{var}(r_i) + 2 \sum_{i \neq j}^{N}\sum^{N} X_i.X_j.\mathrm{cov}(r_i,r_j), \text{ or}$$

$$\sigma_p^2 = \sum_{i=1}^{N}\sum_{j=1}^{N} X_i.X_j.\,\sigma_{ij} \quad . \tag{2-6}$$

In matrix form, it is given by

$$\sigma_p^2 = \underline{X}'\ \underline{V}\ \underline{X} \tag{2-7}$$

where $\underline{X}' = (X_1, X_2, \ldots, X_N)$

$$\underline{V} = \begin{bmatrix} \mathrm{var}(r_1) & \mathrm{cov}(r_1,r_2) & \ldots & \mathrm{cov}(r_1,r_N) \\ \mathrm{cov}(r_2,r_1) & \mathrm{var}(r_2) & & . \\ . & & . & . \\ . & & & . \\ \mathrm{cov}(r_N,r_1) & \ldots & \ldots & \mathrm{var}(r_N) \end{bmatrix}$$

= covariance matrix of the rate of return of the N securities.

Appendix A shows the derivations of the above formulae.

2.2.6 Diversification

The naive definition of diversification used widely by tradtional investment texts of "not putting all one's eggs in one's basket" or "spreading one's risk," is insufficient under Markowitz assumptions. Modern Portfolio Theory [13] shows that there is a limit to the diversification of investment in securities, and that "it implies the 'right kind' of diversification for the 'right reason'." Sharpe [16, p.150] has verified this in his study. Exhibit 2-1 summarizes his results. As diversification is increased

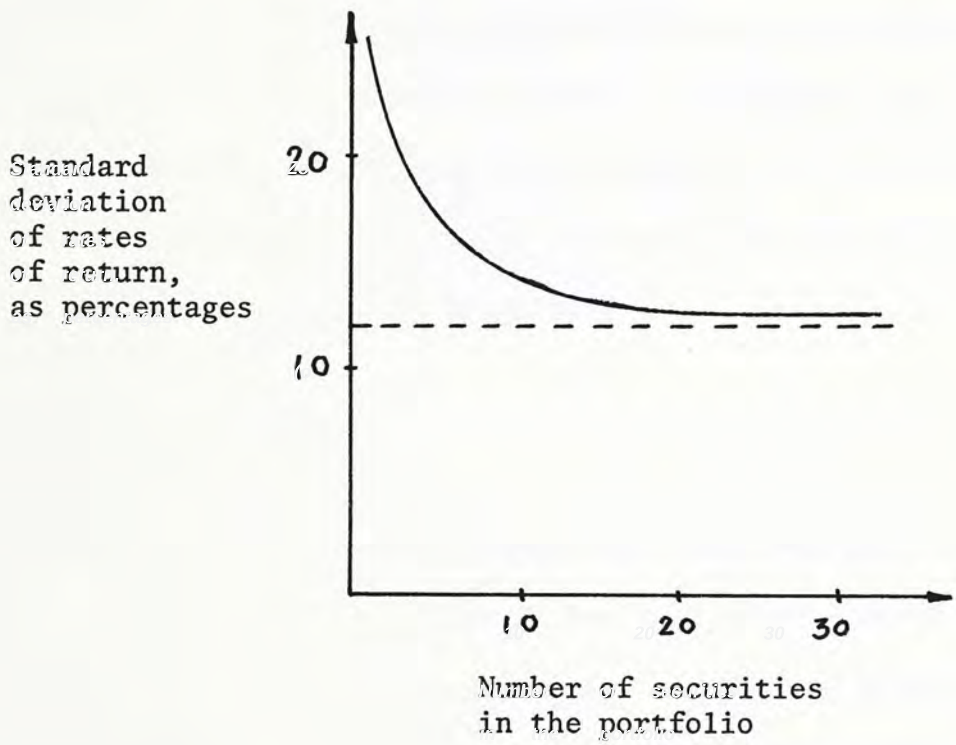


EXHIBIT 2-1 : Limit of Diversification

through increase in the number of securities, the standard deviation of the rate of return falls, at a decreasing rate and approaching a certain limit. In short, the result reveals that a little diversification can go a long way in reducing the variability of the rate of return of the portfolio. As Sharpe has said,

> "A typical portfolio with equal dollar amounts of five securities will have only 14 percent more risk (measured by σ_P) than the most highly diversified portfolio imaginable. A typical portfolio with equal dollar amounts of 10 securities will have only 7 percent more risk than the minimum possible; while a typical portfolio with equal amounts of 20 securities will have only 3 percent more than the minimum."

Essentially Markowitz efficient diversification involves combining investments with less than perfect positive correlation in order to reduce risk in the portfolio without substantially sacrificing any of the portfolio's return. In general, the lower the correlation of the securities in a portfolio, the less risky the portfolio will be, regardless of how risky the securities of the portfolio are when analysed in isolation.

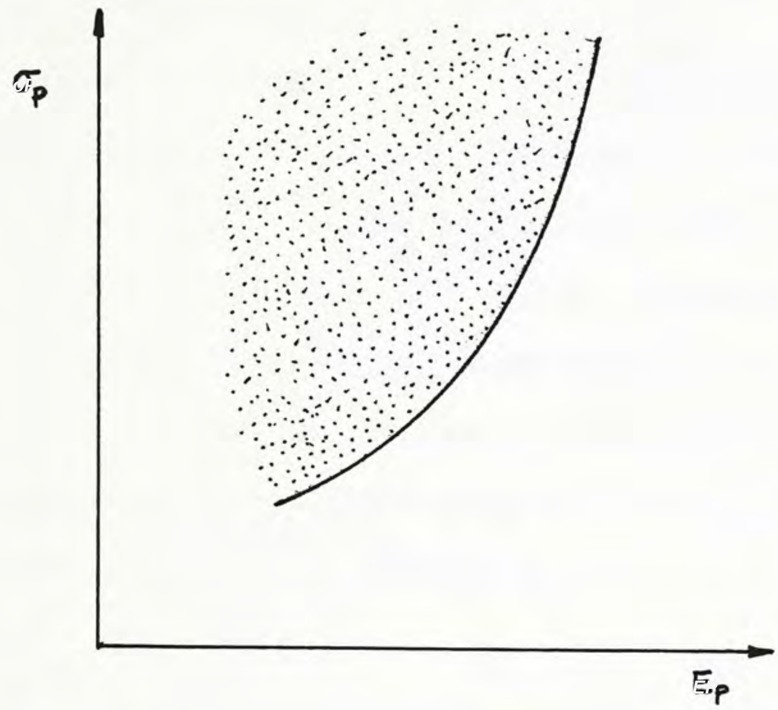
2.2.7 Combining Securities

Modern Portfolio Theory assumes that the investor desires to invest in some efficient portfolio rather than in some portfolio that is not efficient. An efficient portfolio constructed from a list of N securities, with expected return E_p and variance of return σ_p^2 is a portfolio such that :

1. Any other portfolio constructed from the same security list and with expected return E_p has a variance of return greater than σ_p^2; and
2. Any other portfolio constructed from the same security list and variance of return σ_p^2, has an expected return less than

E_p.

The set of all efficient portfolios lies on a curve called the <u>efficient frontier</u>, as shown in Exhibit 2-2. Within the region



<u>EXHIBIT 2-2 : The Efficient Frontier</u>

bounded by the efficient frontier are all the possible combinations of securities for investment. The efficient frontier can be plotted either on a E_p - σ_p^2 graph or a E_p - σ_p graph. The former is better when calculations are involved, while the latter is more suitable for the purpose of interpretation.

2.2.8 <u>Basic Problem of Portfolio Analysis</u>

The basic problem of Portfolio Analysis is to determine the efficient frontier, given the estimates of the prospects of each of the securities. This involves the solution of an "optimization" problem /16, p. 59/. Such a problem usually includes :

1. One or more decision variables, i.e., the proportions, X_i's, in the N securities;
2. One or more constraints placed on the assignment of values to X_i, e.g., the values must always sum to one, or in some cases there may be an upper limit and/or lower limit on the amount invested in a given security or group of securities; and
3. An objective to be maximized or minimized. The objective of any given investor is to select the best portfolio, i.e., to find the feasible portfolio lying on the most desirable "indifference curve[1]." (Exhibit 2-3)

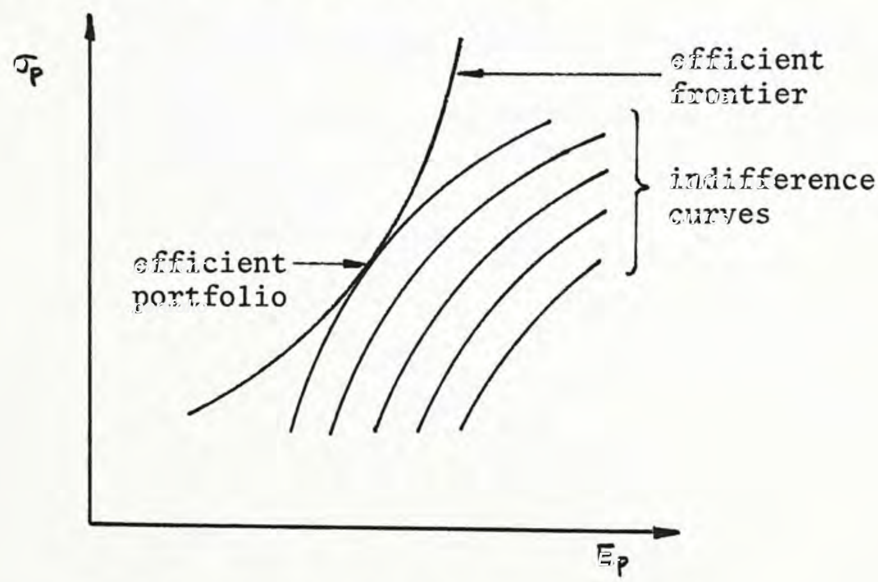


EXHIBIT 2-3 : The Efficient Portfolio

[1]Both Sharpe /16/ and J.C. Francis /6/ have given some discussion on the topic of "indifference curve". For more detailed discussion on indifference curves and decision-making under uncertainty, readers are advised to refer to /2/.

As shown in Exhibit 2-3, the solution of the problem is given by the tangency point where an individual investor's indifference curve just touches the efficient frontier. The solution has two important characteristics :

1. the selected portfolio is efficient; and
2. at the selected point, the indifference curve touches the region but not enters it.

2.2.9 Formulation of the Basic Problem[1]

For the sake of simplicity, assume that the equations of the indifference curves are given by :

$$\sigma_p^2 = \theta \cdot E_p - \alpha_i, \text{ for any integer i.} \qquad (2\text{-}8)$$

α_i indicates the negative value of the vertical intercept for the ith indifference curve (Exhibit 2-4). It increases as the indifference

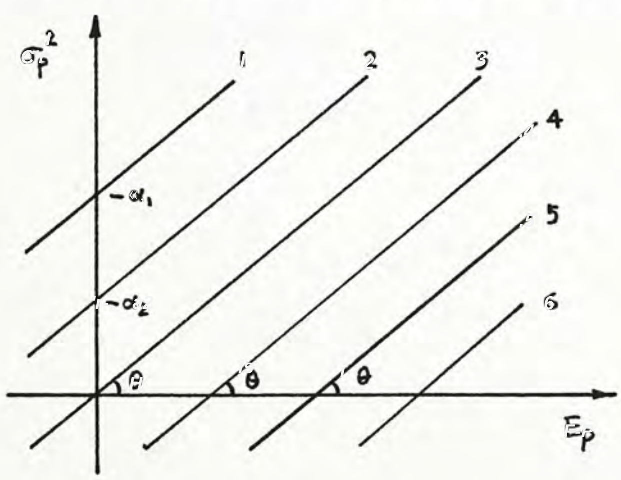


EXHIBIT 2-4 : Indifference Curves

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[1]Most of the discussion presented in this section is abstracted from Sharpe /16, p.60/, with some modifications.

curve shifts towards the left. θ indicates the slope of the indifference curve. The value of θ represents the importance to be accorded E_p relative to σ_p^2 by the investor. It is given the name Risk Preference. This is because the greater the value of θ is, the greater will be the risk which the investor is willing to take in return for greater return for profit. Note that the value of θ will not be less than zero.

The objective of the investor is to find the indifference curve which just touches the efficient frontier but does not enter it. Hence it is to maximize α. Rewriting the equation of the indifference curve as

$$\alpha_i = \theta \cdot E_p - \sigma_p^2 \tag{2-9}$$

The objective of Portfolio Analysis is thus to

(decision variable) select $X_1, X_2, \ldots\ldots, X_N$

(objective) to maximize $\theta \cdot E_p - \sigma_p^2$,

for all possible values of $\theta \geq 0$,

where (2-10)

$$E_p = \sum_{i=1}^{N} X_i \cdot E_i, \text{ and}$$

$$\sigma_p^2 = \sum_{i=1}^{N}\sum_{j=1}^{N} X_i \cdot X_j \cdot \sigma_{ij};$$

(constraints) subject to $\sum_{i=1}^{N} X_i = 1$, and

any other relevant constraints.

2.2.10 The Standard Problem of Portfolio Analysis

Most Portfolio Analysis problems are too complicated to fit the specifications of the basic problem. Such complications arise when the values that may be assigned to the decision variables are typically constrained in various ways. Sharpe [16, p. 64] has expressed the standard problem of Portfolio Analysis as follows:

(Decision variables)	select $X_1, X_2, \ldots\ldots\ldots, X_N,$	
(objective)	to maximize	(2-11)
	$\theta \cdot \sum_{i=1}^{N} X_i \cdot E_i - (\sum_{i=1}^{N}\sum_{j=1}^{N} X_i . X_i . \sigma_{ij}),$	
	for all possible values of $\theta \geq 0$;	
(constraints)	subject to $\sum_{i=1}^{N} X_i = 1,$	
	plus any other linear equality constraints,	
	plus $L_1 \leq X_1 \leq U_1,$	
	$\cdot \quad \cdot \quad \cdot$	
	$L_N \leq X_N \leq U_N.$	

U_i is the upper bound for the proportion invested in security i, while L_i is the lower bound. All Portfolio Analysis problems can be expressed in the above form.

Such a problem is recognised as a mathematical programming one. With the objective function being quadratic and the constraints linear, such a problem is a typical Quadratic Programming one, the solution of which is discussed in the following section. Another less commonly used method of solving the problem is to use the Langrange Multiplier Method[1].

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[1] Francis and Archer [6, p. 92] gave some comments on the use of Langrange Multiplier Method in solving the Quadratic Programming problem.

2.3 INTRODUCTION TO QUADRATIC PROGRAMMING (QP)

A Quadratic Programming problem is a non-linear programming problem having linear constraints and an objective function which is the sum of a linear form and a quadratic form. After introducing slack and surplus variables into the constraints as needed [7] and introducing matrix-vector notations, the quadratic programming problem can be written as :

$$
\begin{aligned}
& \underline{A}\,\underline{X} = \underline{b}, \\
& \underline{X} \geq \underline{0}, \\
\max \quad & z = \underline{C}\,\underline{X} + \underline{X}'\,\underline{D}\,\underline{X},
\end{aligned}
\tag{2-12}
$$

where

there are m constraints and N variables,

$\underline{A}$ is an m x N matrix,

$\underline{D}$ is an N x N matrix (symmetrix),

$\underline{b}$ is an m-component vector, and

$\underline{X}$, $\underline{C}$ are N-component vectors.

The solution of such a QP problem can be done using the "simplex method" developed by Wolfe [19]. Essentially the method (as is true for other non-linear programming problem) is to convert the QP problem to a <u>Linear Programming</u> problem (LP) and use the usual simplex method to solve the LP problem. The above QP problem is thus modified [8, p. 212] to yield a new LP problem of the form :

$$
\begin{aligned}
\underline{Q}\,\underline{W} &= \underline{f}\,, \\
\underline{W} &\geq \underline{0}\,, \\
\underline{X}'\,\underline{V} &= 0\,, \\
\max \quad z &= -\sum_{j=1}^{N} u_j\,;
\end{aligned}
\qquad (2\text{-}13)
$$

where[1]

$$
\underline{Q} = \begin{bmatrix} \underline{A} & \underline{0} & \underline{0} & \underline{0} & \underline{0} \\ 2\underline{D} & -\underline{A}' & \underline{A}' & \underline{I}_N & \underline{E} \end{bmatrix}
$$

where $\underline{I}_N$ is an N x N identity matrix,

$\underline{E} = \|\Delta_j \delta_{ij}\|$ and is a diagonal matrix whose diagonal elements are $\Delta_j = \pm 1$,

$$
\underline{W} = (\,\underline{X},\ \underline{\zeta},\ \underline{\xi},\ \underline{V},\ \underline{U}\,)\,,
$$

where $\underline{\zeta}$, $\underline{\xi}$, $\underline{V}$, and $\underline{U}$ are non-negative artificial variables adding to the original set of equations (2-12),

$\underline{U}' = (\,u_1, \ldots, u_N\,)$,

$$
\underline{f} = (\,\underline{b},\ -\underline{C}'\,)\,.
$$

The problem is linear except for the restriction $\underline{X}'\,\underline{V} = 0$. It can be solved by using the familiar revised simplex method developed by Hadley [8] for solving LP problems.

---

[1] For details of derivations and explanation of notations, refer to [8, p.214].

2.4 QUADRATIC PROGRAMMING FOR SOLVING THE PROBLEM

With some modifications, the standard problem can be put in the form shown in equation (2-12) and hence could be solved using the revised simplex method. However, because of the complications and the tedious iterations in the computational procedures in using the simplex method, the solution could not be attained without the use of computer facilities. Several computer package programs have been developed such as the one developed by the RAND Corporation[1] to solve the QP problem. Paine /14/ has made use of the computer package in his study of Portfolio Selection. The author has developed his own program to solve the particular QP problem because of the unavailability of any other QP program for the ICL 1904A computer. Details are presented in Chapter 4.

2.5 CONCLUSION

The Portfolio Theory presented has been centered around the original idea of Markowitz. Since then a number of modifications to the Theory have been made to make it more practicable and simpler. Sharpe, one of Markowitz's students, was among those who succeeded in putting forth a simpler but still rigorous model to solve the typical portfolio problem. This is presented in the following chapter.

---

[1] The RAND Corporation of Santa Monica, California, developed a QP code to be solved by an IBM 7090 in 1962. Since then modifications have been made to the program to suit the changing requirements.

CHAPTER 3

CONSTRUCTION OF A MODEL

3.1 OBJECTIVES OF HAVING THE MODEL

Under the theory put forward by Markowitz, it has been pointed out that for a N-securities portfolio, the analysis of the N securities requires N expected returns, N variances and $\frac{1}{2}(N^2 - N)$ covariances. Furthermore, all these estimates will have to be input and analysed to yield the final result. As Markowitz [13, p. 96] had pointed out, such computational procedures require a lot of time and are uneconomical even with the help of the computer. In order to reduce the effort involved in preparing and processing the data for a Portfolio Analysis problem, Markowitz suggested certain sophistications that might simplify the procedures. Following his suggestion, Sharpe developed an ingenious simplified model of Portfolio Analysis called the Sharpe's Diagonal Model or the Single-index Model. Sharpe's model requires less input data; the data can be tabulated more simply, and the solution process simplifies certain necessary calculations. Thus the objectives of treating risk in portfolio investment in quantitative terms and finding the efficient frontier can be achieved with less effort.

3.2 THE MODEL - ASSUMPTIONS AND RELATIONS

Sharpe /15, p. 277/ assumed that the returns of various securities are related to each other through a common relationship with some index of business activities, and that the covariance of any two securities can be disregarded. Thus for the ith security and period t, the return on investment is given by :

$$r_{it} = a_i + b_i \cdot I_t + e_{it}, \text{ and} \qquad (3\text{-}1)$$

$$\sigma_{ij} = \operatorname{cov}(r_i, r_j) = 0, \text{ for all } i \neq j;$$

where

r_{it} = return on the ith security at time t,

a_i = regression parameter (y-intercept),

b_i = regression parameter (slope),

I_t = return on some market index H at time t,

e_{it} = random-error term for the ith security at time t, and

σ_{ij} = covariance between ith and jth securities.

The variables a_i and b_i are generally termed as the <u>Alpha coefficient</u> and the <u>Beta coefficient</u> respectively. The significance of these terms will be discussed later. The <u>random-error term</u>, e_{it} ($= r_{it} - a_i - b_i \cdot I_t$), can be regarded as a prediction error. It represents the difference between the actual rate of return and the best estimate of its value, given the level of return of the market index. There are several <u>assumptions</u> about the random-error term:

1. $E(e) = 0$, i.e., the random-error terms average out to zero;
2. $\operatorname{var}(e)$ = constant;
3. $\operatorname{cov}(e, I_t) = 0$, i.e., the e's are uncorrelated with the

return of the index;

4. $cov(e_{it}, e_{i\ t+n}) = 0$, i.e., the e's are not serially correlated, and

5. $cov(e_i, e_j) = 0$, i.e., the e's of one security is uncorrelated with any other security's e's.

Using Linear Regression technique, the regression line with return on ith security against return on market index can be found such as the one shown in Exhibit 3-1. This regression line with the equation $r_i = a_i + b_i.I$ is given the name <u>Characteristic Line</u>.

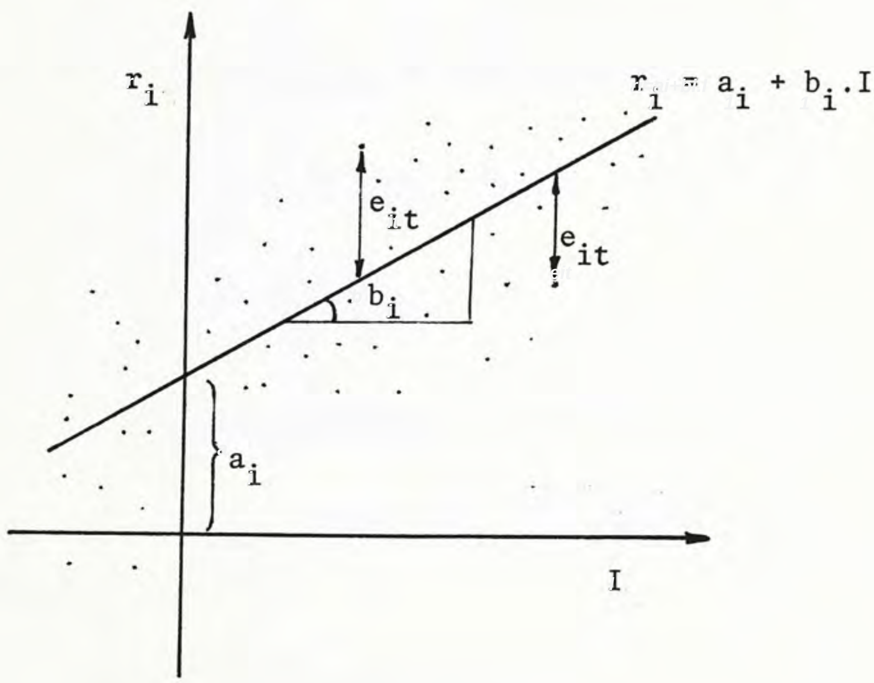

EXHIBIT 3-1 : The Characteristic Line

From the above assumptions and definitions, the following formulae are derived (see Appendix B) for the expected return and variance of the ith security.

$$E(r_i) = a_i + b_i \cdot E(I), \text{ and} \qquad (3\text{-}2)$$

$$var(r_i) = b_i^2 \cdot var(I) + var(e_i) \qquad (3\text{-}3)$$

3.3 APPLYING THE MODEL TO FIT THE BASIC PROBLEM OF PORTFOLIO ANALYSIS

Consider a portfolio with N securities. The portfolio's return is given by (see Appendix C)

$$r_p = \sum_{i=1}^{N} X_i \cdot (a_i + e_i) + X_{N+1} \cdot I, \qquad (3\text{-}4)$$

where

$$X_{N+1} = \sum_{i=1}^{N} X_i \cdot b_i.$$

The expected return on the portfolio is then given by

$$E_p = E(r_p) = \sum_{i=1}^{N} X_i \cdot a_i + X_{N+1} \cdot E(I) \qquad (3\text{-}5)$$

By denoting $a_{N+1} = E(I)$,

$$E_p = \sum_{i=1}^{N+1} X_i \cdot a_i$$

The variance of return on the portfolio is given by (see Appendix C)

$$\sigma_p^2 = \sum_{i=1}^{N} X_i^2 \cdot var(e_i) + X_{N+1}^2 \cdot var(I) \qquad (3\text{-}6)$$

By denoting $var(e_{N+1}) = var(I)$,

$$\sigma_p^2 = \sum_{i=1}^{N+1} X_i^2 \cdot var(e_i).$$

The significance of the name "diagonal model" can be seen from the last equation. The covariance matrix has zeros in all positions other than the diagonal elements, as shown below [6, p. 100],

$$\underline{V} = \begin{bmatrix} var(e_1) & 0 & \cdots & 0 \\ 0 & var(e_2) & & \cdot \\ & & \cdot & \\ \cdot & & \cdot & 0 \\ 0 & \cdots & 0 & var(e_{N+1}) \end{bmatrix}$$

Thus the basic problem of Portfolio Analysis can now be rephrased as[1]:

(decision variables) to select $X_1, X_2, \ldots\ldots, X_N$,

(objective) to maximize $\theta \cdot E_p - \sigma_p^2$,
for all possible values of $\theta \geq 0$,

where

$$E_p = \sum_{i=1}^{N+1} X_i . a_i, \text{ and} \tag{3-7}$$

$$\sigma_p^2 = \sum_{i=1}^{N+1} X_i^2 . var(e_i);$$

(constraints) subject to

$$\sum_{i=1}^{N} X_i = 1,$$

$$\sum_{i=1}^{N} X_i . b_i = X_{N+1}, \text{ and}$$

any other relevant constraints.

3.4 GENERATING STATISTICAL INPUTS

The return of the market is measured by the rate of change of an economic market index H, i.e.,

$$I_t = \frac{H_{t+1} - H_t}{H_t} \tag{3-8}$$

---

[1]Note the upper subscripts of the sigma signs.

where

H_{t+1} = the value of the index at the beginning of period t+1, and

H_t = the value of the index at the beginning of period t.

The <u>rate of return of the ith security</u> for which the characteristic line is being prepared is calculated using the following equation,

$$r_{it} = \frac{P_{t+1} + D_t - P_t}{P_t} \tag{3-9}$$

where

P_t = market price at the beginning of period t,

P_{t+1} = market price at the beginning of period t+1, and

D_t = dividend for period t.

The characteristic line $r_i = a_i + b_i.I$ is estimated by the usual least-square regression method; the values of the regression parameters, namely the <u>Alpha and Beta coefficients</u>, can be determined using the formulae : (see Appendix D)

$$b_i = \frac{\text{cov}(r_i, I)}{\text{var}(I)}, \text{ and} \tag{3-10}$$

$$a_i = \overline{r}_i - b_i.\overline{I} \tag{3-11}$$

The <u>variance of the random-error term</u> is calculated using the equation (3-3), reproduced as below :

$$\mathrm{var}(e_i) = \mathrm{var}(r_i) - b_i^2 \cdot \mathrm{var}(I) \qquad (3\text{-}3)$$

3.5 SOME INTERPRETATIONS AND USES OF THE MODEL

Besides determining the efficient portfolios with simplifications, Sharpe's model indicates that risk can be partitioned into two distinct elements. Statistically, for any security, total risk is measured by the variance of returns. This measure of total risk can be partitioned into the systematic (or market) risk and unsystematic (or non-market) risk, as given by equation (3-3), reproduced as follows:

$$\mathrm{var}(r_i) = \underbrace{b_i^2 \cdot \mathrm{var}(I)}_{\text{systematic risk}} + \underbrace{\mathrm{var}(e_i)}_{\text{unsystematic risk}} \qquad (3\text{-}3)$$

The systematic risk is that portion of a change in the return of an individual security which can be attributed to the movement of the market as a whole such as might be characterized by a change in the market index (Hang Seng Index). These systematic changes are common to all stocks and are nearly impossible to diversify away. The unsystematic risk is that portion of a change in the return unique to the specific security. Modern Portfolio Theorists assert that by making use of Markowitz diversification for a portfolio of securities, the overall unsystematic risk can be effectively reduced. This topic will be discussed again after the Beta and Alpha coefficients are presented.

The characteristic line

$$r_i = a_i + b_i \cdot I$$

describes the relationship between the returns on the ith security and the returns on the market. b_i, the Beta coefficient (or simply Beta), is the slope of the regression line. This gives the amount of stock returns per unit of market return. When b_i is equal to one, then on the average 10 percent expected return on the market will be associated during the same period of time with a 10 percent expected return on the stock. When b_i is greater than one, this means on the average, the stock's expected return will be greater than the market's expected return, and conversely when b_i is less than one. The Beta coefficient represents the "sensitivity of the security's return" towards changes in market return. In other words, it measures the degree to which the security participates in overall movements in the market index.

The Alpha coefficient (or simply Alpha), a_i, is the "y-intercept" of the regression line. It represents the amount of return produced by the stock, on the average, independent of the return of the market. It measures the specific component of a stock's return. It can be positive, zero or negative.

Hence the return on each security can be regarded as being composed of two components: the Alpha coefficient which represents the "intrinsic" return of the stock, irrespective of the market's return, and the "$b_i \cdot I$" term, which represents the return by investing in the market.

For a portfolio, the return and risk can be similarly considered. The portfolio's return is given by equation (3-5), reproduced as follows :

$$E_p = \underbrace{\sum_{i=1}^{N} X_i \cdot a_i}_{\text{basic return of securities}} + \underbrace{X_{N+1} \cdot E(I)}_{\text{investment in market index}} \qquad (3\text{-}5)$$

The portfolio's return can be regarded as being composed of two parts: the first term considered as intrinsic return of the "basic securities", and the second term as the return on investment in the market index.

The portfolio's risk is given by equation (3-6) (reproduced below)

$$\sigma_p^2 = \underbrace{\sum_{i=1}^{N} X_i^2 \cdot var(e_i)}_{\text{unsystematic risk}} + \underbrace{X_{N+1}^2 \cdot var(I)}_{\text{systematic risk}} \qquad (3\text{-}6)$$

X_{N+1}, which is equal to $\sum_{i=1}^{N} X_i \cdot b_i$, is referred to as the portfolio's Beta coefficient (or simply Beta). This represents the "market sensitivity of the portfolio" and is the weighted average of the market sensitivities of the component securities, using the relative amounts, X_i's, as weights. The contribution of an individual security to the total risk of a portfolio is measured by the Beta of that security.

The equation (3-6) has great significance in Modern Portfolio Theory. It breaks down the portfolio's risk into two terms - the systematic (market) and the unsystematic (non-market) risks. The latter is "controllable" by means of efficient diversification of the portfolio. This is explained as follows: Modern Portfolio Theory asserts that diversification reduces the unsystematic element of portfolio risk. As the process of diversification continues, the positive variations in return caused by the unsystematic risk of some securities, tend to be offset by the negative specific variation in return of other securities. It has been shown [17, p. 150] that as N, the number of securities, increases with diversification, the unsystematic risk term decreases and tends to zero as N tends to infinity. Roughly, the portfolio's risk [4, p. 404] can be approximated as

$$\sigma_p^2 = (\frac{1}{N} + 1) \cdot X_{N+1}^2 \cdot var(I) \qquad (3\text{-}12)$$

In the limiting case when N is very large, $\sigma_p^2 \approx X_{N+1}^2 \cdot var(I)$. In actual practice, the unsystematic risk can never be reduced to zero. As Merrill Lynch [3, p. 771] remarked "In a typical diversified investment portfolio of thirty or more common stocks, diversification eliminated so much of the specific (unsystematic) risk that roughly 85 to 90 percent of all the risk is systematic risk, and only 5 to 15 percent is unsystematic risk."

Hence, as a conclusion, to a certain degree of approximation, the portfolio's risk is given by the variance of the market index times the square of the portfolio's Beta. Also, the portfolio's return will be given exactly by the equation (3-5), i.e., essentially it becomes a function of the portfolio's Beta. As a result, the comparative returns and risks of alternative well-diversified portfolios can be measured by comparing their Betas. Other things being equal, the greater the portfolio's Beta, the greater the return and the risk of the portfolio, and vice versa. The significance of the conclusion thus derived can be understood when the model is applied to a number of securities in the Hong Kong Securities Market.

CHAPTER 4

APPLICATION OF THE MODEL TO SELECTED HONG KONG SECURITIES

Once the Single-index Model has been constructed, the Portfolio Theory can be put into practice by the portfolio analyst for any stock market in which he wishes to invest, provided he satisfies certain requirements. In this chapter, we will apply the Sharpe's Model to a number of securities in the Hong hong Stock Market to illustrate how the foregoing theories can be put into practice. Some of the results will be shown, together with interpretations. As the thesis is concerned mainly with Portfolio Analysis, the procedures of Security Analysis and Portfolio Selection will only be touched upon slightly.

4.1 GLOBAL PICTURE OF PORTFOLIO ANALYSIS

Our Portfolio Analysis study starts with the selection of a certain number of securities, and a suitable market index as an indicator of the market performance. Having chosen the securities and the index, the required data for some specific dates within a given period of time are selected. From these data, statistical inputs required by the Quadratic Programming program are computed. Finally the efficient frontier together with a few efficient portfolios are constructed. The procedures for the whole analysis are summarized in Exhibit 4-1.

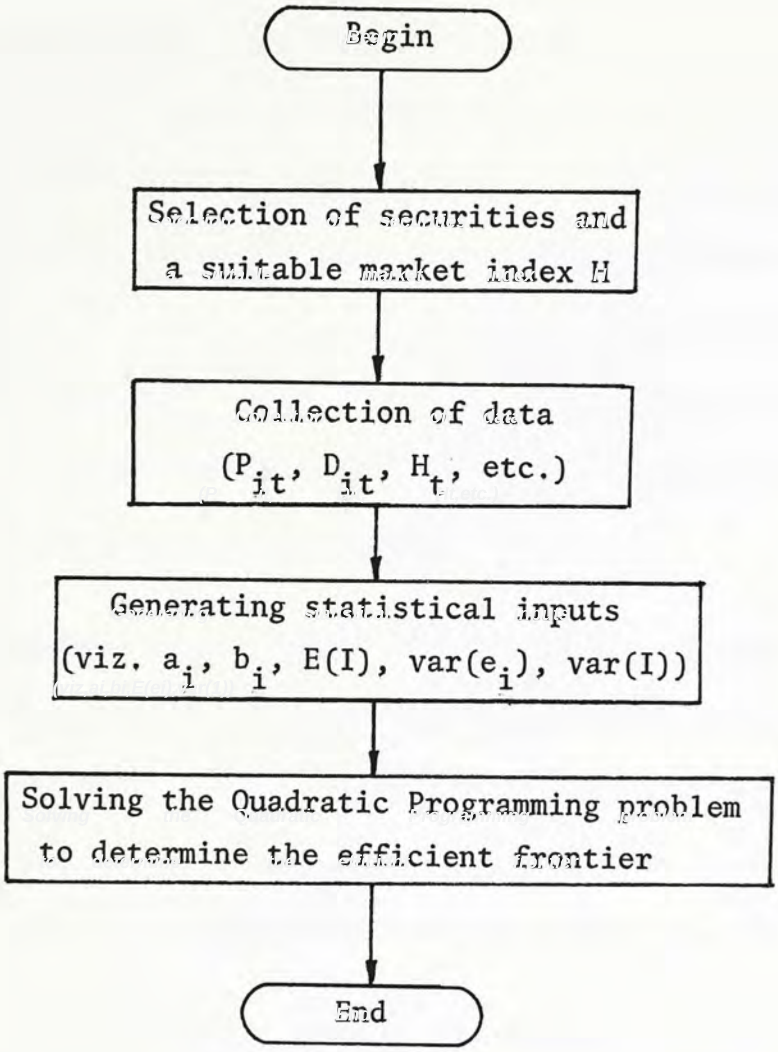

EXHIBIT 4-1 : Portfolio Analysis for Selected Hong Kong Securities

4.2 SELECTION OF SECURITIES AND THE MARKET INDEX

The Hang Seng Index [9] has been chosen as the indicator of the performance of the market. The Index was first introduced in 1964 (with base 100 on 31st July, 1964) and has been, and still is, used by investors and other interested parties for following the stock price movements on the Hong Kong Stock Exchange by means of comparing the daily market values of the issued shares of the constituent stocks. As of the time of this research, there were thirty-three constituent stocks. Not only is the Hang Seng Index the most popular and familiar to investors, brokers and the like, in Hong Kong and elsewhere[1], but also it is by far the oldest. That it is the most popular and familiar makes it easier for people to accept it as an indicator of the market performance. The fact that its values can be obtained as far back as 1964 enables the author to apply Sharpe's Single-Index Model in the Hong Kong Stock Market.

The period chosen is from the beginning of 1968 until the end of 1973, a total of six years. Just before 1968, there was a slump in the Hong Kong Stock Market. Beginning in 1968, the market gradually recovered and prospered until 1973 when it became "bear" again. Thus the period considered represents more or less a complete cycle.

Because of the limitations of computer time and core size, only twenty stocks were analysed. Also, since this is a demonstrative study, a few number of securities would facilitate the analysis and interpretation. The stocks were chosen from the Hang Seng constituent stocks because firstly, they were important stocks (blue chips), and secondly, there may be a better relationship between the price movements of the stocks and the market, as given by the characteristic line, and hence better results of analysis. Theoretically, we can choose any stocks

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[1]From personal interviews with stock brokers, investment analysts by the author.

and any number of them which are traded in the Hong Kong Stock Market and analyse them using Sharpe's Model. Also Security Analysis of all the stocks in the stock market should, in fact, be carried out to make initial screening and analysed thoroughly each and every stock so as to arrive at the decision of selecting the desired stocks.

The way the stocks were selected is described below. First of all the stocks were screened according to whether or not data for the stocks were available as early as 1968. Then the list of twenty stocks were chosen such that there would be at least one representative stock for each industry (so as to be Markowitz diversified). The industry with the largest number of stocks chosen will be the one considered by the portfolio analyst as the most lucrative one, after he has made a preliminary survey of the industries of Hong Kong. Exhibit 4-2 is a list of the twenty stocks selected for study. Having determined the stocks to be selected, the next step is to collect specific data for the stocks.

4.3 COLLECTION OF DATA

The period from 1st January, 1968 till 1st January, 1974 was considered. Data were collected at the beginning of each quarter-year period. A total of twenty-four quarter-year periods yielded altogether twenty-four sets of data for the index and each stock. Most of the data were obtained from the Hong Kong Stock Exchange, while the rest were obtained from stock exchange year books and monthly gazettes and newspapers.

Exhibit 4-3 shows the data collection form for collecting the Hang Seng Index figures for the dates specified. The dates denote

Security No.	Name of Stock	Industry (code)
1	HK Bank	Banking (1)
2	HK & Yau	Transport (9)
3	K.M. Bus	Transport (9)
4	Jard. Sec.	Investment (2)
5	E.A. Nav.	Shipping (3)
6	HK Dock	Dockyard (4)
7	Swire	Dockyard (4)
8	HK & K Wh	Wharf & Godown (5)
9	HK Land	Land (6)
10	HK Realty	Land (6)
11	HK Hotel	Hotel (7)
12	City Hotel	Hotel (7)
13	C. Light	Public Utility (8)
14	HK Tel.	Public Utility (9)
15	HK Gas	Public Utility (9)
16	L. Craw.	Food & Store (10)
17	Jardine	Commerce (11)
18	Wheelock	Commerce (11)
19	Watsons	Commerce (11)
20	Alliance	Textile (12)

EXHIBIT 4-2 : List of Twenty Stocks

the beginning of the quarter-year periods and are the days on which there were tradings at the Hong Kong Stock Exchange.

For each of the securities selected, the dates used were the same as that shown in Exhibit 4-3. Exhibit 4-4 gives a list of all the data required for each stock considered. Essentially, the specific data required for the stocks include the market price (in dollars amount), stock split and stock dividend (expressed as per share values), cash dividend (in dollars amount), property dividend and rights issued. By

Period	date	Hang Seng Index
1	2/ 1/68	
2	1/ 4/68	
3	2/ 7/68	
4	1/10/68	
5	2/ 1/69	
6	1/ 4/69	
7	2/ 7/69	
8	1/10/69	
9	2/ 1/70	
10	1/ 4/70	
11	2/ 7/70	
12	1/10/70	
13	4/ 1/71	
14	1/ 4/71	
15	2/ 7/71	
16	1/10/71	
17	3/ 1/72	
18	4/ 4/72	
19	3/ 7/72	
20	2/10/72	
21	2/ 1/73	
22	2/ 4/73	
23	3/ 7/73	
24	1/10/73	
25	2/ 1/74	

1 10

EXHIBIT 4-3 : Data-collection Form I

DATA-COLLECTION FORM II

NO. ______
79 80

Name of Firm ______________________________
1 64
Abbreviation of name ______________ Industry ______________
66 75 76 77
Type/history of stock ______________ Source ______________

Period	date (quarter-year)	market price ($)	stock split (per share)	stock divi. (per share)	cash divi. ($)	property divi.	rights issued (value, no. & date issued)
1	2/ 1/68		- -	- -	- -	- -	- -
2	1/ 4/68						
3	2/ 7/68						
4	1/10/68						
5	2/ 1/69						
6	1/ 4/69						
7	2/ 7/69						
8	1/10/69						
9	2/ 1/70						
10	1/ 4/70						
11	2/ 7/70						
12	1/10/70						
13	4/ 1/71						
14	1/ 4/71						
15	2/ 7/71						
16	1/10/71						
17	3/ 1/72						
18	4/ 4/72						
19	3/ 7/72						
20	2/10/72						
21	2/ 1/73						
22	2/ 4/73						
23	3/ 7/73						
24	1/10/73						
25	2/ 1/74						
		1 10	11 20	21 30	31 40	41	50

EXHIBIT 4-4 : Data-collection Form II

property dividend we mean the dividend received in the form of stock of another company. For any rights issued, the value, number of rights and dates issued were recorded.

4.4 GENERATING STATISTICAL INPUTS

Exhibit 4-5 gives a list of all variables and a summary of their formulae required for the Quadratic Programming problem. The chart is self-explanatory and requires little comments except in the case of computing the returns on each security. In calculating the return for a stock, the following assumptions are required:

1. Stocks received as the result of stock split and stock dividend are retained until all holdings are liquidated.
2. For any property dividend issued, the stock received is sold at the average of the high price and the low price on the payment of the dividend.
3. Any stock rights received in period t are sold at the average of the high price and the low price for the first trading day of period t+1.
4. All brokerage fees, commission and transfer taxes are ignored.

The return for any stock in period t is then defined as follows: It is the decimal equivalent of a fraction which has as its denominator the total amount invested at the beginning of period t and which has as its numerator the following:

Begin

For each period t and ith security, READ in the required data

Market Index	H_t
Market Price	P_{it}
Dividend	D_{it}
Stock dividend	SD_{it}
Stock split	SS_{it}
Rights, etc.	R_{it}

Calculation of :

Return on ith security and the Market Index

$$r_{it} = \frac{P_{i,t+1} . SS_{i,t+1} . (1+SD_{i,t+1}) + D_{i,t+1} + R_{i,t+1} - P_{it}}{P_{it}}$$

$$I_t = \frac{H_{t+1} - H_t}{H_t}$$

Expected return on the security and the Market Index

$$E(r_i) = \sum_{t=1}^{m} r_{it} \;/\; m$$

$$E(I) = \sum_{t=1}^{m} I_t \;/\; m$$

Variance of the returns

$$var(r_i) = \sum_{t=1}^{m} (r_{it} - E(r_i))^2 \;/\; m-1$$

$$var(I) = \sum_{t=1}^{m} (I_t - E(I))^2 \;/\; m-1$$

Beta coefficient, Alpha coefficient and variance of the random-error term

$$b_i = \frac{\sum_{t=1}^{m} (I_t - E(I)).(r_{it} - E(r_i))}{\sum_{t=1}^{m} (I_t - E(I))^2}$$

$$a_i = E(r_i) - b_i.E(I)$$

$$var(e_i) = var(r_i) - b_i^2.var(I)$$

Print out the results

Graphs and tables

Stop

EXHIBIT 4-5 : Summary of Flowchart for Generating Statistical Inputs

1. Proceeds from liquidation of holdings at the beginning of period t+1, plus
2. Proceeds from cash dividends received in period t, plus
3. Proceeds from sale of property dividends in the form of stocks of another company received in period t, plus
4. Proceeds from the sale of stock rights at the beginning of period t+1, minus
5. Total amount invested at the beginning of period t [14].

Symbolically, the return for the ith stock in period t is given by:

$$r_{it} = \frac{P_{i.t+1} \cdot SS_{i.t+1} \cdot (1 + SD_{i.t+1}) + D_{i.t+1} + R_{i.t+1} - P_{it}}{P_{it}} \qquad (4\text{-}1)$$

where

$P_{i.t+1}$ = market price of stock at beginning of period t+1 (\$),

$SS_{i.t+1}$ = stock split in period t (expressed as per share values; $\geq$ 1),

$SD_{i.t+1}$ = stock dividend received in period t (expressed as per share values; $\geq$ 0),

$D_{i.t+1}$ = cash dividend in period t (\$),

$R_{i.t+1}$ = proceeds from sale of stock rights and property dividends at the beginning of period t+1 (\$), and

P_{it} = market price of stock at beginning of period t (\$).

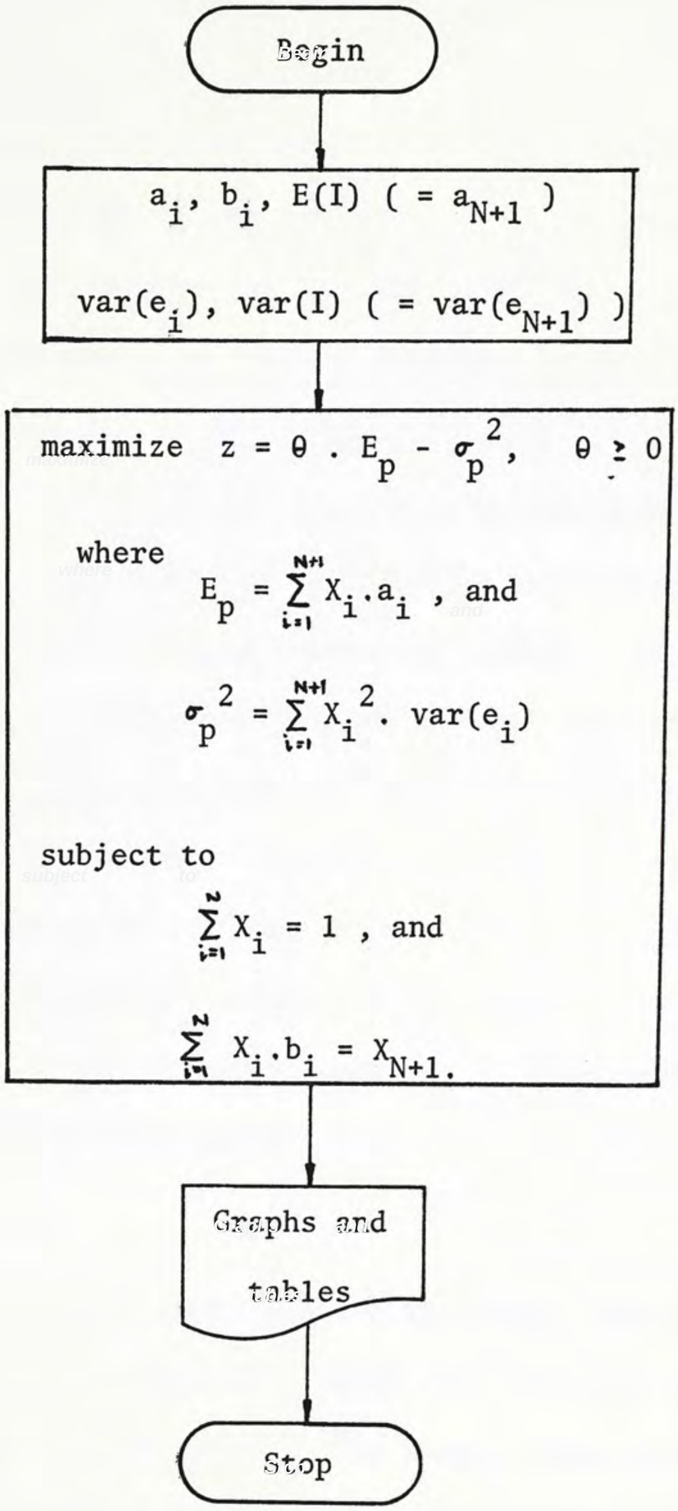
4.5 SOLVING THE QUADRATIC PROGRAMMING PROBLEM

Exhibit 4-6 gives a summary of the procedures for solving the Quadratic Programming problem. The statistical inputs generated in the last stage, namely, a_i, b_i, E(I), var(e_i) and var(I) are fed into Program II (discussed in the following section). The problem is then solved to yield the efficient frontier and the efficient portfolio if the risk preference, θ, of the investor is given.

4.6 ALGORITHMS FOR GENERATING STATISTICAL INPUTS AND SOLVING THE QUADRATIC PROGRAMMING PROBLEM

Programs have been developed by the author in order to solve the Portfolio Analysis problem. Three programs, written in FØRTRAN and processed by an ICL 1904A computer, were used. Program I (Appendix E) is used for generating statistical inputs, the flowchart of which is summarized in Exhibit 4-5. The second program (Appendix F) is used to solve the basic problem of Portfolio Analysis, i.e., the Quadratic Programming problem. The flowchart of the program is summarized in Exhibit 4-6. With minor alterations of the algorithms, Program II can be modified to solve any standard problem of Portfolio Analysis. Program III (Appendix G) plots the efficient frontier and, given the risk preference of the investor, constructs the efficeint portfolio, together with a summary of data about the stocks.

4.7 RESULTS AND INTERPRETATIONS



READ in the required statistical inputs

Solve the particular Quadratic Programming problem to determine the optimal proportions, X_i's

Print out the results

EXHIBIT 4-6 : Summary of Flowchart for Solving the Quadratic Programming Problem

4.7.1 The Market Index

The data for the twenty-four time periods and the corresponding rates of change of the Hang Seng Index were obtained from Program I, as listed in Exhibit 4-7. The printout also contains the average rate of change and the variance of rate of change of the Index. The former figure indicates the average performance of the market in the last six-year period. At the level of risk specified by the variance of the rate of change of the index, an average stock is expected to earn at a return of 10.75 percent over a quarter-year period. At the same level of risk, any stock whose rate of return is less than 10.75 percent is considered to have performed less satisfactorily than the average stock, e.g., the Utility stocks. Conversely, a stock is said to perform better than the market if its rate of return is greater than 10.75 percent; one example is the Swire stock. The variance of rate of change gives one an idea of "how risky" the market is, in general. The larger this number is, the greater is the risk of the market, and vice versa.

Exhibit 4-8 plots the market index against the years, and shows how the index has moved for the period. In Exhibit 4-9, the rate of change of the market index is plotted against the years. Some interesting points can be noted from these three printouts. At period 1, the Index and the rate of change of the Index were 63.12 and -0.5659 respectively. The negative rate of change of the Index and the Index of 63.12 compared with a base of 100 in 1964 suggested there was then a bear stock market. Since then the market recovered gradually and steadily

EXHIBIT 4-7

HANG SENG MARKET INDEX

PERIOD	QUARTER YEAR		HANG SENG INDEX	RATE OF CHANGE OF INDEX
1	68	I	63.12	-0.0659
2	68	II	72.37	0.1465
3	68	III	87.16	0.2044
4	68	IV	116.51	0.3367
5	69	I	112.53	-0.0342
6	69	II	118.63	0.0542
7	69	III	141.41	0.1920
8	69	IV	155.38	0.0988
9	70	I	176.95	0.1388
10	70	II	183.68	0.0380
11	70	III	197.81	0.0769
12	70	IV	213.26	0.0781
13	71	I	210.38	-0.0135
14	71	II	305.89	0.4540
15	71	III	349.61	0.1429
16	71	IV	346.81	-0.0080
17	72	I	355.21	0.0242
18	72	II	448.36	0.2622
19	72	III	500.86	0.1171
20	72	IV	869.14	0.7353
21	73	I	1234.05	0.4199
22	73	II	604.18	-0.5104
23	73	III	513.57	-0.1500
24	73	IV	432.78	-0.1573

AVERAGE RATE OF CHANGE : 0.1075

VARIANCE OF RATE OF CHANGE : 0.0575

EXHIBIT 4-8

PLOT OF MARKET INDEX AGAINST TIME

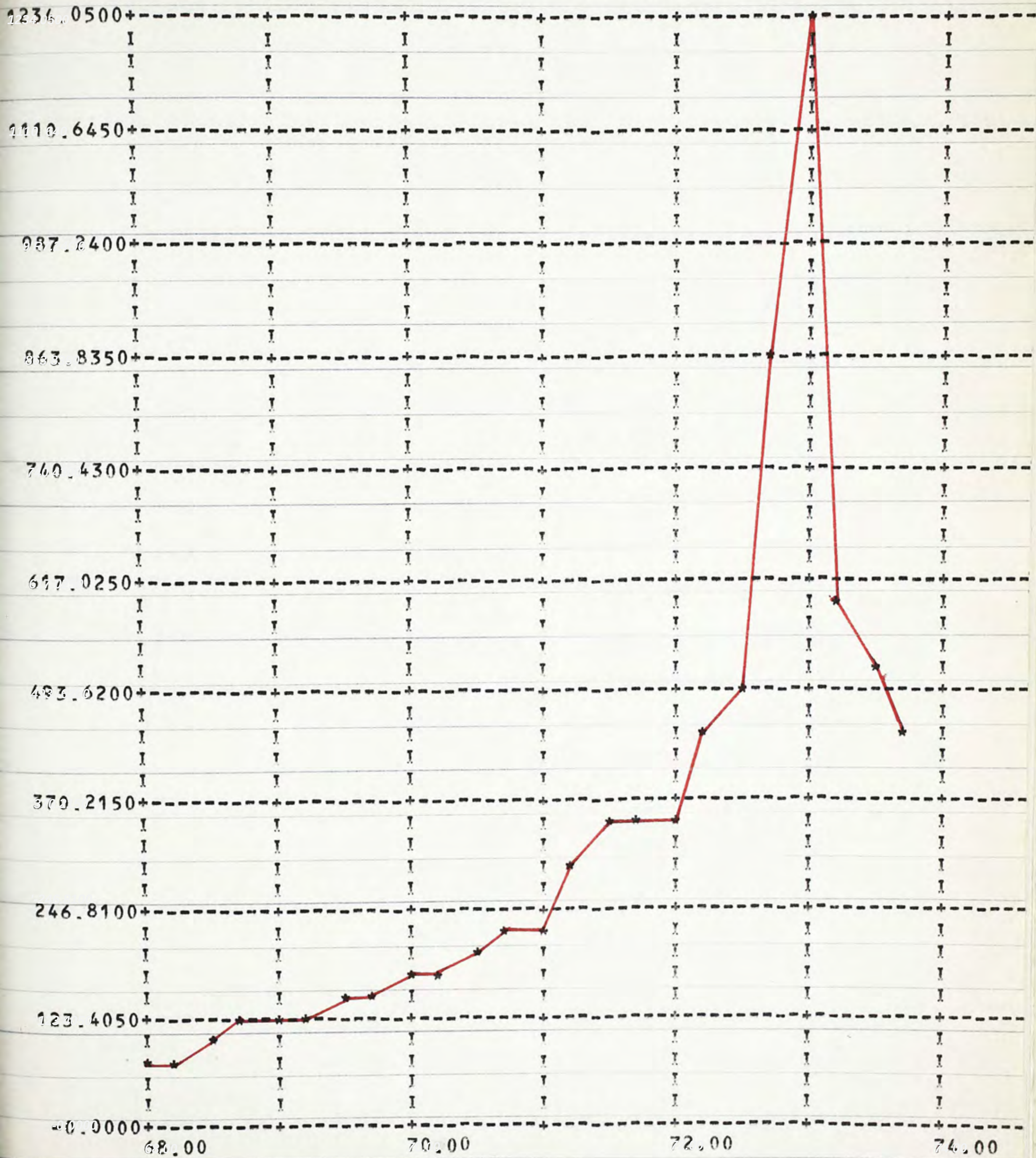
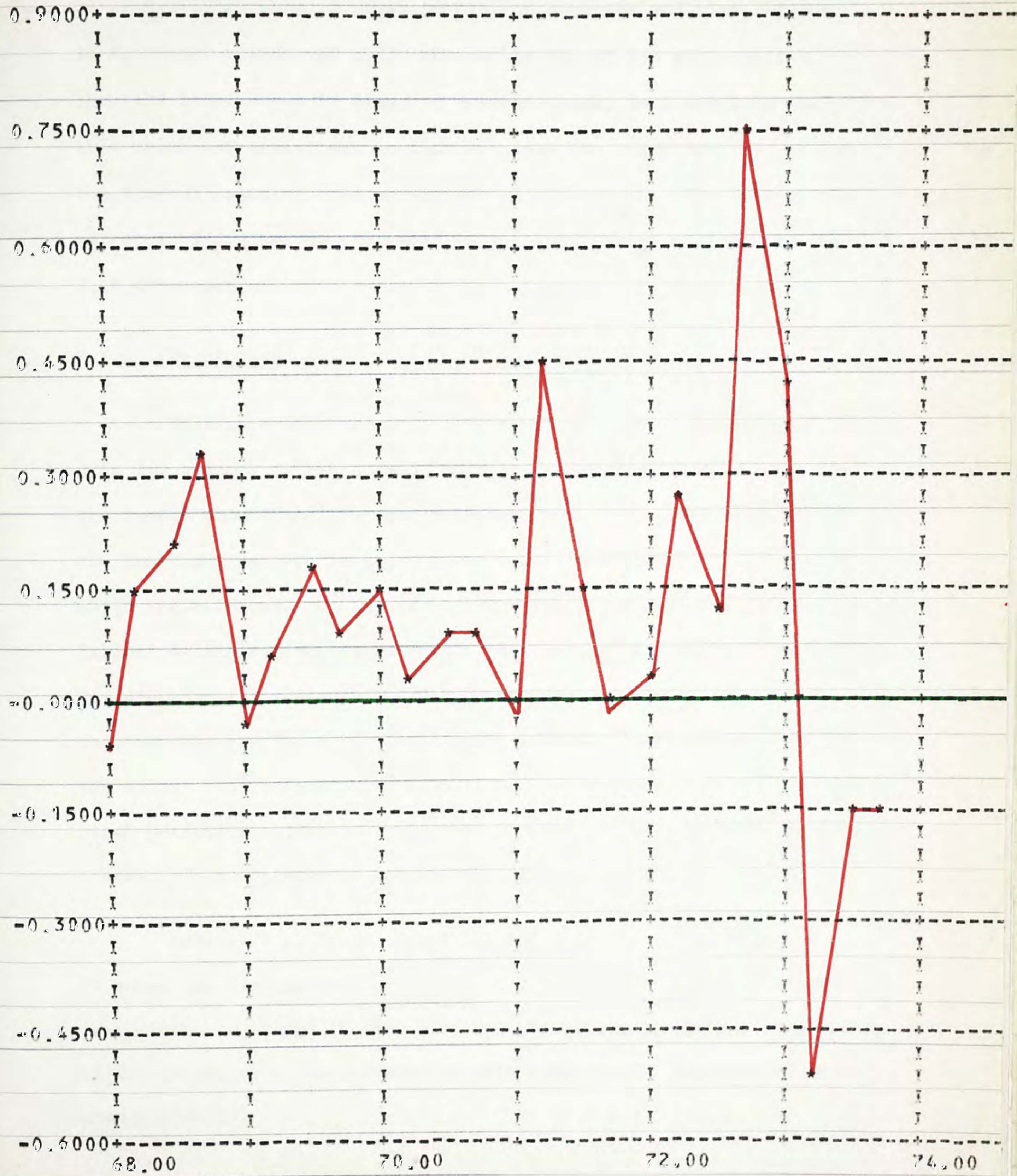


EXHIBIT 4-9

PLOT OF RATE OF CHANGE OF MARKET INDEX AGAINST TIME



until mid-1972, when it began to pick up momentum and rise rapidly. In the first quarter of 1973, the market was at its most bullish. Then the Index began to drop, at immense speed, to a level in early 1974 which was equivalent to that attained two years earlier. As of the time of research, the market was still bearish. The fall of the market is indicated by the negative rates of change of Index in the last three period.

4.7.2 The Stocks

Exhibit 4-10 gives, out of a total of twenty, a sample of the data for a stock obtained from Program I. The whole lot of data for the twenty stocks are produced in Appendix H. The sheet contains all the facts and data collected for the stock, and some of the variables which are necessary for inputs into the Portfolio Analysis problem. Exhibit 4-11 plots the market price of a stock which has been adjusted for stock splits and/or stock dividends, against time. Appendix I contains the graphs for all the twenty stocks. These graphs show how the stocks had performed in the period. For example, the Alliance stock performed extraordinarily well in 1969 as compared with the average stocks. This suggested a boom of the industry during the period.

Exhibit 4-12 is an example of the graphs given in Appendix J. It shows the fluctuations of the rate of change of the stock's market price with the change in time. In bull market, positive and large rates of change dominate, and in bear market, persistently negative rates of change prevail.

EXHIBIT 4-10

Data Output Sample for a Stock

THE HONGKONG AND SHANGHAI BANKING CORPORATION 1

HK BANK BANKING

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	131.00	1.00	0.00	4.56	0.00	0.0041
2	68	II	140.00	1.00	0.00	0.00	0.00	0.0687
3	68	III	153.00	1.00	0.00	3.50	0.00	0.1179
4	68	IV	199.00	1.00	0.00	0.00	0.00	0.3007
5	69	I	173.00	1.00	0.10	5.46	0.00	-0.0163
6	69	II	191.00	1.00	0.00	0.00	0.00	0.1040
7	69	III	204.00	1.00	0.00	4.00	0.00	0.0890
8	69	IV	246.00	1.00	0.00	0.00	0.00	0.2059
9	70	I	152.00	1.00	1.00	3.50	0.00	0.2500
10	70	II	155.00	1.00	0.00	0.00	0.00	0.0197
11	70	III	163.00	1.00	0.00	1.68	0.00	0.0625
12	70	IV	185.00	1.00	0.00	0.00	0.00	0.1350
13	71	I	172.00	1.00	0.10	3.50	0.00	0.0416
14	71	II	266.00	1.00	0.00	0.00	0.00	0.4302
15	71	III	260.00	1.00	0.00	1.75	0.00	0.0640
16	71	IV	270.00	1.00	0.00	0.00	0.00	0.0385
17	72	I	242.00	1.00	0.10	3.50	0.00	-0.0011
18	72	II	282.00	1.00	0.00	0.00	0.00	0.1653
19	72	III	258.00	1.00	0.00	1.75	0.00	-0.0789
20	72	IV	388.00	1.00	0.00	0.00	0.00	0.5039
21	73	I	236.00	1.00	0.20	3.75	0.00	-0.2604
22	73	II	31.00	10.00	0.00	0.00	0.00	0.3136
23	73	III	27.10	1.00	0.00	0.20	0.00	-0.1194
24	73	IV	28.80	1.00	0.00	0.00	0.00	0.0627

AVERAGE RETURN : 0.1042

VARIANCE OF RETURN : 0.0287

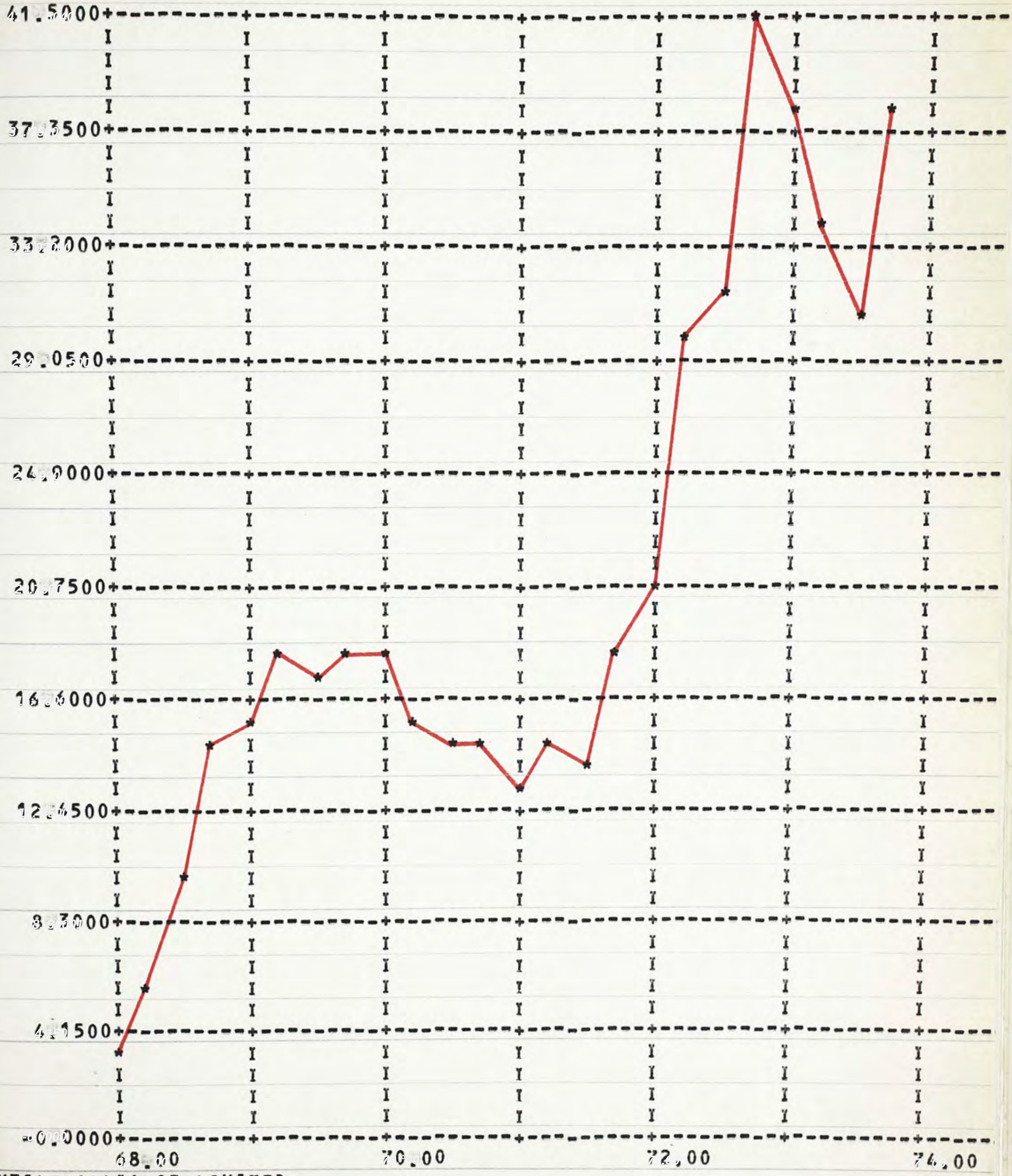
STANDARD DEVIATION : 0.1693

ALPHA COEFFICIENT : 0.0792

BETA COEFFICIENT : 0.2326

EXHIBIT 4-11 : A Graphic Output Sample of Adjusted Price Against Time For a Stock

FIGURE 20



TEXTILE ALLIANCE LIMITED

EXHIBIT 4-12 : A Graphic Output Sample of Rate of Change of Price Against Time for a Stock

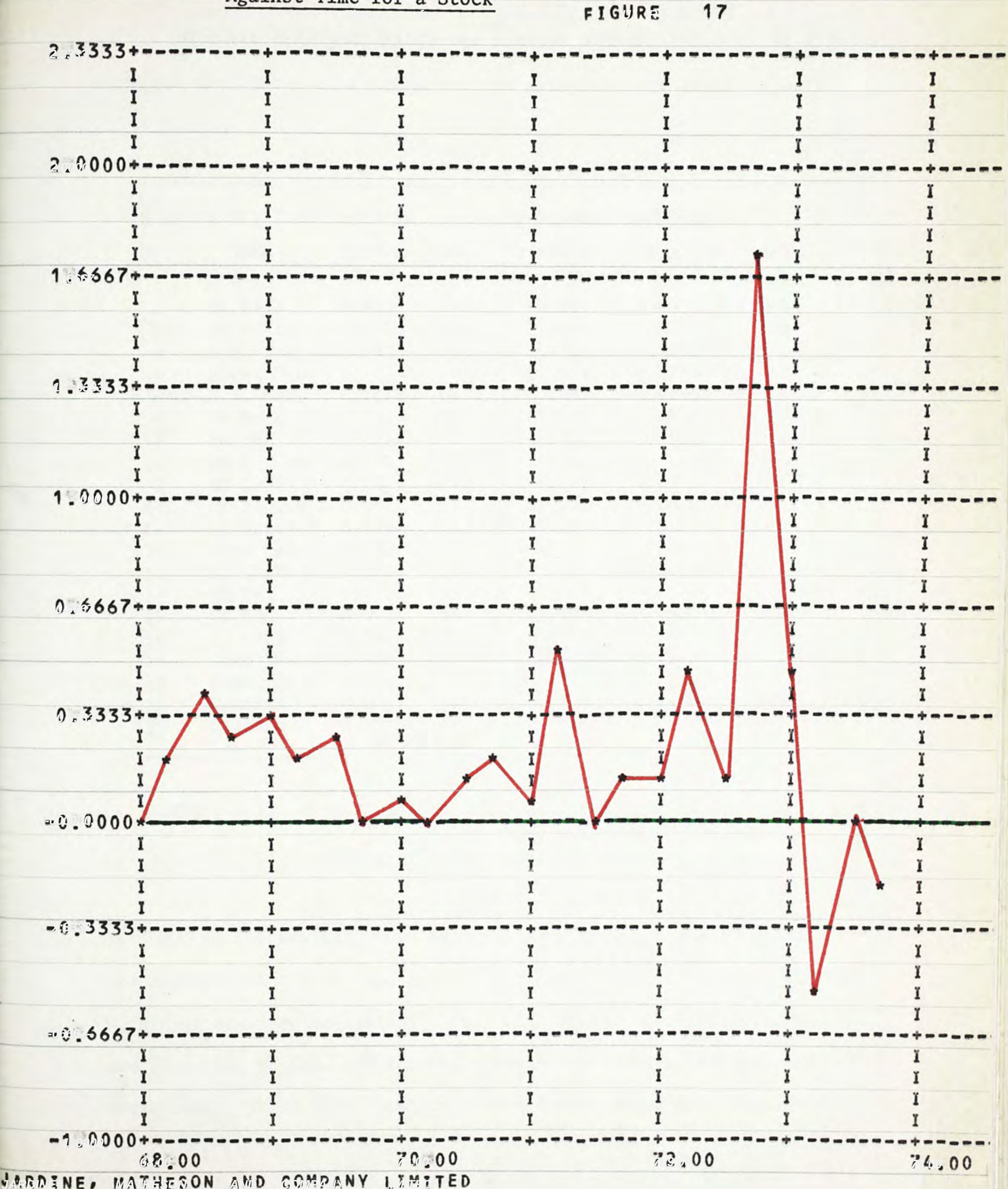


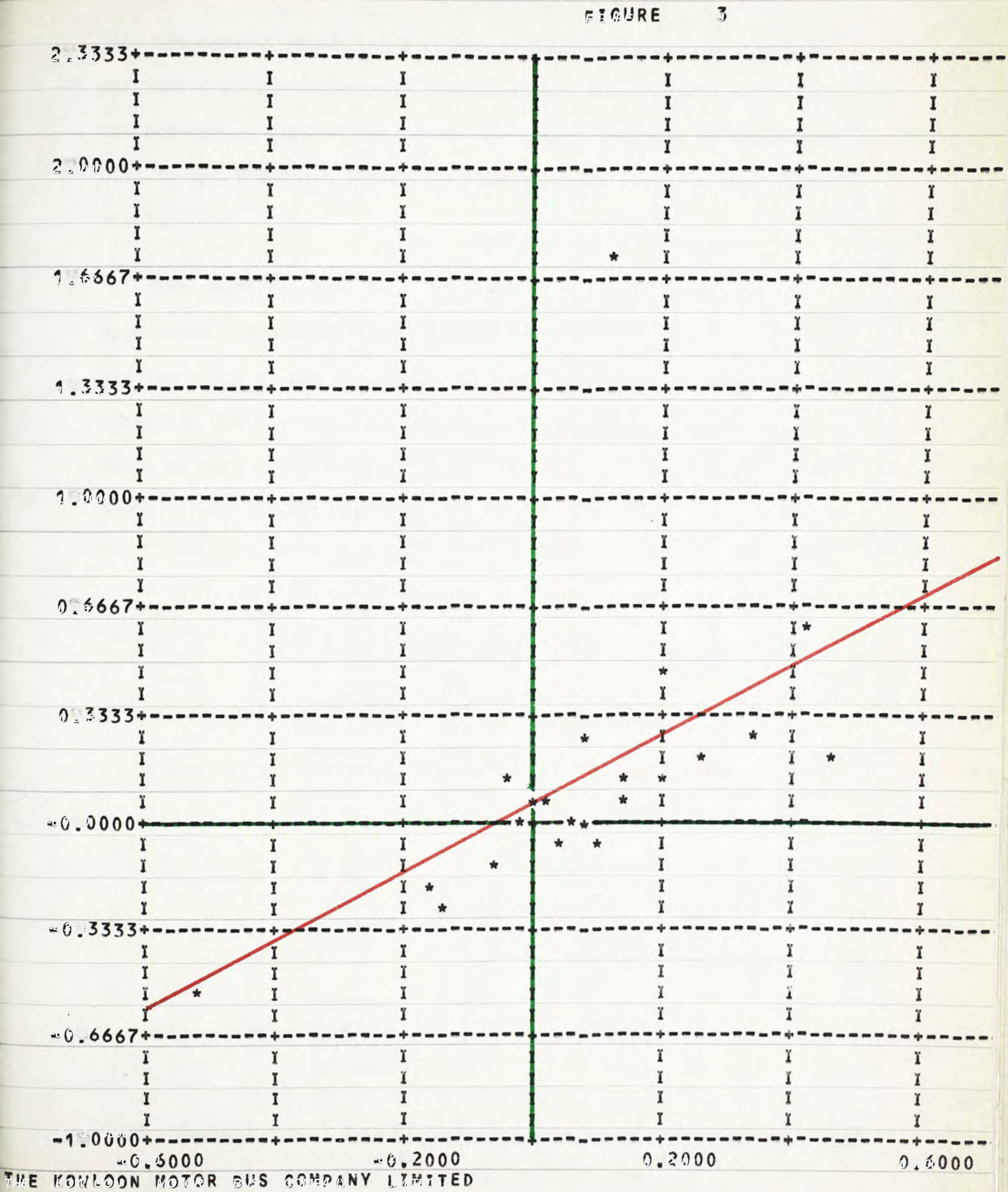
Exhibit 4-13 summarizes the average return, variance of return, standard deviations of return, and the ranks for the twenty stocks.

SECURITY NO.	NAME	AVERAGE RETURN	RANK	VARIANCE OF RETURN	STANDARD DEVIATION	RANK
1	HK Bank	0.1042	13	0.0287	0.1693	20
2	HK & Yau	0.0459	20	0.0448	0.2117	16
3	K.M. Bus	0.1638	6	0.1851	0.4303	1
4	Jard. Sec.	0.1324	9	0.0556	0.2358	13
5	E.A. Nav.	0.1655	5	0.1358	0.3685	3
6	HK Dock	0.1315	10	0.0655	0.2559	10
7	Swire	0.1784	3	0.1153	0.3395	4
8	HK & K Wh	0.1901	2	0.1084	0.3293	5
9	HK Land	0.1590	7	0.0970	0.3115	8
10	HK Realty	0.1021	14	0.0626	0.2522	11
11	HK Hotel	0.1754	4	0.0997	0.3157	6
12	City Hotel	0.1220	11	0.0731	0.2704	9
13	C. Light	0.0894	15	0.0435	0.2086	17
14	HK Tel.	0.0792	17	0.0350	0.1871	18
15	HK Gas	0.0634	19	0.0348	0.1866	19
16	L. Craw	0.0878	16	0.0976	0.3124	7
17	Jardine	0.2092	1	0.1615	0.4019	2
18	Wheelock	0.1150	12	0.0523	0.2288	15
19	Watsons	0.0792	18	0.0550	0.2345	14
20	Alliance	0.1555	8	0.0629	0.2508	12

EXHIBIT 4-13 : List of Returns, variances and Standard Deviations of All Stocks

As Shown in the exhibit, the three stocks with the highest returns are Jardine, HK & K Wh, and Swire. These stocks are always associated with high standard deviations, i.e., high risks. The lowest three are HK & Yau, HK Gas, and Watsons. Again, these have low standard deviations. There is a total of twelve stocks which have done better

EXHIBIT 4-14 : An Example of Characteristic Line



than the market, which has a return of 10.75 percent over the last six years, at the expense of greater risk. Those stocks which did not perform as well as the market are generally those in the Public Utility and Transport Industries; but they are normally the "safer" stocks.

The characteristic lines of the twenty stocks were shown in Appendix K. One example is given in Exhibit 4-14. The y-intercept and the slope of the regression line are respectively the Alpha coefficient and the Beta coefficient of the stocks. The Alphas and Betas of all twenty stocks and their ranks are summarized in Exhibit 4-15. There are six stocks having Beta greater than 1.00. These

S E C U R I T Y		A L P H A		B E T A	
NO.	NAME	COEFF.	RANK	COEFF.	RANK
1	HK Bank	0.0792	2	0.2326	20
2	HK & Yau	-0.0314	20	0.7184	14
3	K.M. Bus	0.0580	5	0.9844	7
4	Jard. Sec.	0.0662	4	0.6153	16
5	E.A. Nav.	0.0669	3	0.9169	10
6	HK Dock	0.0221	14	1.0167	6
7	Swire	0.0341	10	1.3426	2
8	HK & K Wh	0.0538	6	1.2672	3
9	HK Land	0.0252	12	1.2439	4
10	HK Realty	0.0023	17	0.9282	9
11	HK Hotel	0.0449	9	1.2128	5
12	City Hotel	0.0282	11	0.8725	11
13	C. Light	0.0103	15	0.7355	13
14	HK Tel.	0.0093	16	0.6500	15
15	HK Gas	0.0006	18	0.5844	17
16	L. Craw	-0.0171	19	0.9755	8
17	Jardine	0.0522	7	1.4603	1
18	Wheelock	0.0223	13	0.8616	12
19	Whatsons	0.0616	8	0.2563	19
20	Alliance	0.1185	1	0.3443	18

EXHIBIT 4-15 : List of Alpha and Beta Coefficients of All Stocks

stocks will have, on the average, expected returns greater than the market's expected return within the period considered. However, at the time the stock market collapsed, these stocks suffered more than the average stocks. The rest of the stocks have Betas of less than 1.00. These stocks are less sensitive to the market movements. Therefore, when the market trend is downward, these stocks will suffer less than the average stocks. Typical examples are the Public Utility and Transport stocks.

Taking HK Bank for illustration, this stock has a very high Alpha, but the smallest Beta of all. It means that the stock has a high return independent of the market, and that the price movement of the stock is very insensitive to the market fluctuations. This stock would be a good buy at a time when the market is bearish. This is verified from our interviews with local investment analysts. Furthermore, this is in accordance with the slogan now prevailing on Wall Street: "keep your Alpha high and your Beta low" /3, p. 52/. On the other hand, when a bull market prevails, stocks with high Betas, such as Jardine or HK & Wh stocks, are preferred, because these stocks are most sensitive to the market. Remember that the return of stock is given by the Alpha plus the product of Beta and the return of the market. In order to gain advantage of the large return on the market, stocks with high Betas are preferred. These stocks will, most probably, yield high returns on investment.

4.7.3 <u>The Efficient Frontier</u>

Using Program II, the efficient frontier was plotted as shown in Exhibit 4-16. As predicted, the curve is convex. As the return of the portfolio, E_p, increases, the portfolio's risk, σ_p^2, increases accordingly at an increasing rate. Around the region where the portfolio's return is about 21 percent, an infinitesimal increase in return causes a tremendous increase in the risk of the portfolio. The curve is made up of portfolios which satisfy the dual investment criteria :

1. highest expected return for a given level of risk, and
2. lowest level of risk for a given level of expected return.

The portfolio analyst is supposed to locate and invest in a portfolio along this curve, provided his risk preference is given.

Exhibit 4-17 is an example of an efficient portfolio for an investor with risk preference, θ, equalled to 0.4. The portfolio is represented in Exhibit 4-16 as "P". For each stock, the rate of return, standard deviation of return, Alpha and Beta coefficients and their ranks are also given. The last column is the portfolio for the investor, i.e. the fractions of his funds to be invested in each of the stocks on the original list of stocks. For those stocks having fractions with zero values, no investment is made. Note that in this portfolio there are altogether six stocks. The values of the fractions add up to a total of 1.00, representing the total sum of funds available. The return of the portfolio is 18.90 percent, which is the weighted average of the returns of the stocks, with the fractions of investment as weights. The standard deviation of return of the portfolio is 0.3249.

EXHIBIT 4-16

PLOT OF EFFICIENT FRONTIER WITH STANDARD DEVIATION AGAINST EXPECTED RETURN

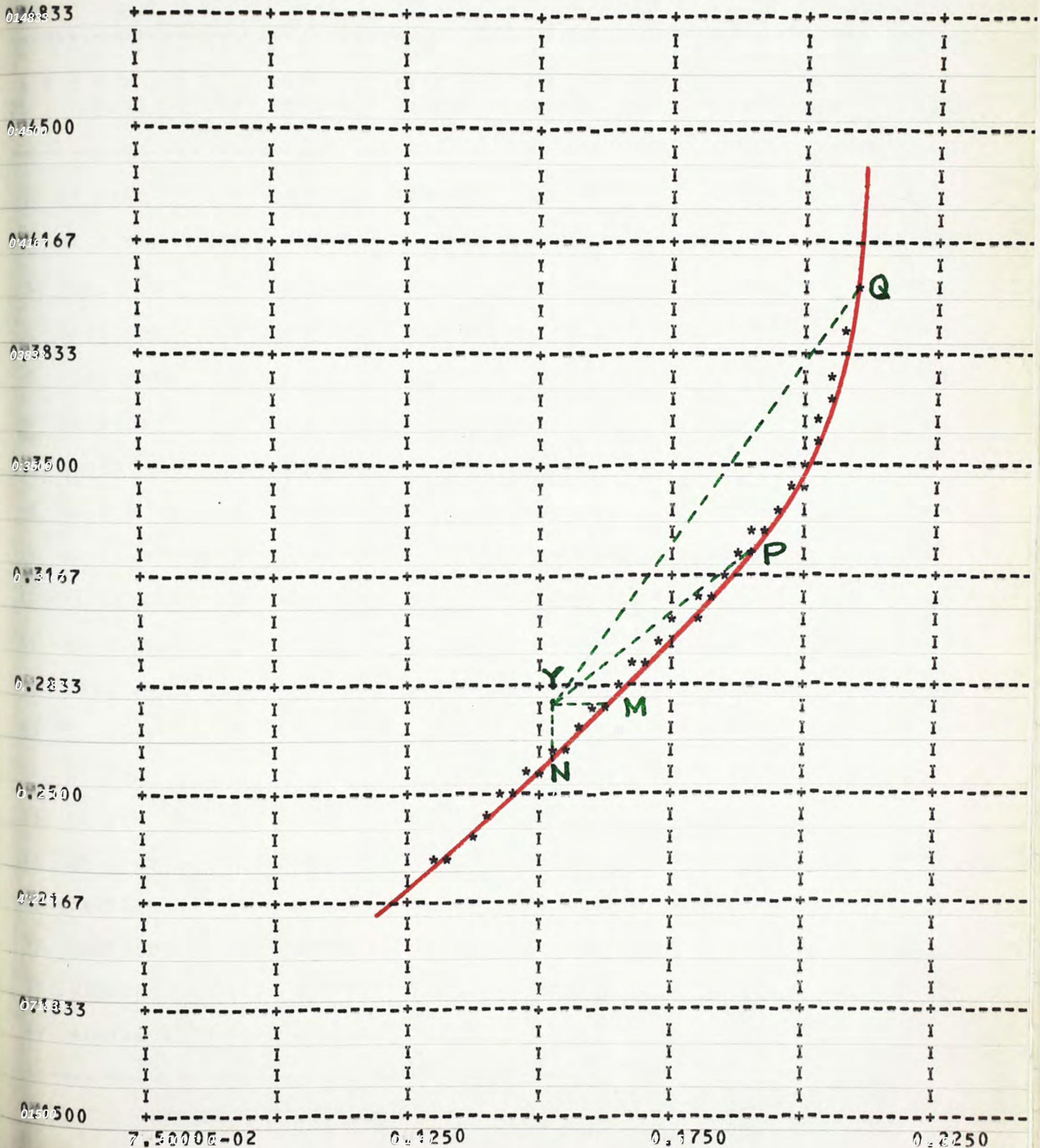


EXHIBIT 4-17 : An Example of an Efficient Portfolio

T H E   P O R T F O L I O

RISK PREFERENCE = 0.4000

SECURITY NO	SECURITY NAME	SECURITY IND	RATE OF RETURN	STANDARD ERROR	ALPHA COEFF	ALPHA RANK	BETA COEFF	BETA RANK	FRACTION
1	HK BANK	1	0.1042	0.1693	0.0792	2	0.2326	20	0.0000
2	HK & YAU	9	0.0459	0.2117	-0.0314	20	0.7184	14	0.0000
3	K.M. BUS	9	0.1638	0.4303	0.0580	5	0.9844	7	0.0011
4	JARD SEC	2	0.1324	0.2358	0.0662	4	0.6153	16	0.0000
5	E.A. NAV.	3	0.1655	0.3685	0.0669	3	0.9169	10	0.0054
6	HK DOCK	4	0.1315	0.2559	0.0221	14	1.0167	6	0.0000
7	SWIRE	4	0.1784	0.3395	0.0341	10	1.3426	2	0.2615
8	HK & K WH	5	0.1901	0.3293	0.0538	6	1.2672	3	0.3339
9	HK LAND	6	0.1590	0.3115	0.0252	12	1.2439	4	0.0000
10	HK REALTY	6	0.1021	0.2522	0.0023	17	0.9282	9	0.0000
11	HK HOTEL	7	0.1754	0.3157	0.0469	9	1.2128	5	0.1615
12	CITY HOTEL	7	0.1220	0.2704	0.0282	11	0.8725	11	0.0000
13	C. LIGHT	8	0.0894	0.2086	0.0103	15	0.7355	13	0.0000
14	HK TEL.	8	0.0792	0.1871	0.0093	16	0.6500	15	0.0000
15	HK GAS	8	0.0634	0.1866	0.0006	18	0.5844	17	0.0000
16	L. CRAW	10	0.0878	0.3124	-0.0171	19	0.9755	8	0.0000
17	JARDINE	11	0.2092	0.4019	0.0522	7	1.4603	1	0.2366
18	WHEELOCK	11	0.1150	0.2288	0.0223	13	0.8616	12	0.0000
19	WATSONS	11	0.0792	0.2345	0.0516	8	0.2563	19	0.0000
20	ALLIANCE	12	0.1555	0.2508	0.1185	1	0.3443	18	0.0000

RETURN : 0.1890

STANDARD ERROR : 0.3249

BETA COEFFICIENT : 1.3216

The Beta coefficient refers to the portfolio's Beta. It can be seen that as θ increases, the Beta, the portfolio's return and the standard deviation of return increase too.

Partitioning the portfolio's risk into its components, the systematic and unsystematic risk, one can see that the former risk accounts for about 95 percent of the total risk. The remaining 5 percent of risk is attributed to the unsystematic risk. Markowitz diversification has been able to reduce the unsystematic risk to the 5 percent level.

$$\begin{array}{lcll}
\text{systematic risk} & = & X_{N+1}^{2} \cdot \operatorname{var}(I) & = 0.1003436\ (\ 95\%) \\
\text{unsystematic risk} & = & \sum_{i=1}^{N} X_i^{2} \cdot \operatorname{var}(e_i) & = 0.00519428(\ \ 5\%) \\
\hline
\text{Total risk} & = & \sum_{i=1}^{N+1} X_i^{2} \cdot \operatorname{var}(e_i) & = 0.10553788(100\%)
\end{array}$$

Consider a portfolio "Y" whose compositions and partitions of the risk are given as follows:

Security No.	Fraction
2	1/8
3	1/8
5	1/8
7	1/8
8	1/8
11	1/8
16	1/8
17	1/8
	1.0

$$E_p = \sum_{i=1}^{N+1} X_i \cdot E_i = 0.1529$$

$$\sigma_p^2 = \sum_{i=1}^{N+1} X_i^{2} \cdot \operatorname{var}(e_i) = 0.2763$$

$$\text{Beta} = 1.1098$$

systematic risk	=	92%
unsystematic risk	=	8%
Total risk	=	100%

The portfolio is shown in Exhibit 4-16. It lies within the efficient frontier and hence, by definition, is inefficient. Under Markowitz assumptions, the investor will try either to maximize his return on investment at the given level of risk or minimize risk at the same level of return. Portfolios "M" and "N" approximate the two situations respectively. Note that their unsystematic risk have been greatly reduced by Markowitz diversification. On the other hand, if securities

	Portfolio M (same risk)	Portfolio N (same return)
E_p	0.1615	0.1524
σ_p^2	0.2764	0.2623
Beta	1.1416	1.0845
systematic risk	97%	98%
unsystematic risk	3%	2%

number 2 and 16 are deleted from the portfolio, and if the fractions as shown in the portfolio of Exhibit 4-17 are used, the investor can shift his portfolio "Y" to the efficient portfolio "P". By so doing, he can reduce the unsystematic risk to the 5 percent level.

Considering an extreme case, the investor can invest in only one stock, namely the security with number 17, represented by "Q" in Exhibit 4-16. This enhances his return at the expense of heavy risk. Furthermore, the one-stock portfolio does not take advantage of Markowitz diversification and hence its unsystematic risk is unavoidably large (25 percent).

σ_p^2	= 0.2092
Beta	= 1.4603
systematic risk	= 0.1225 (75 %)

unsystematic risk	=	0.0390 (25 %)
total risk	=	0.1615 (100 %)

4.8 Conculsion

We have seen how Sharpe's Model is applied for a few selected securities in the Hong Kong Stock Market. In the following chapter, we shall present, as a conclusion of the study, a discussion on the limitations and possible modifications of the model.

CHAPTER 5

CONCLUSION

We have demonstrated how Modern Portfolio Theory can be applied, using Sharpe's Model, to a selected sample of common stocks in Hong Kong. However, Modern Portfolio Theory is not limited to security investment only. Because the Theory handles risk in an explicit manner and because interrelationships between individual entities are also considered, the theory has found its way in other investment problems too. Smith [17, p. 312] gave a discussion on the application of Portfolio Theory in various investment problems; these include option writing, commodity markets, international investment, conglomerate diversification, asset management and capital budgeting. Although such applications are still in their infant stage of development, it will not be surprising that Portfolio Theory will gain acceptance in these financial areas eventually.

Much empirical evidence has been put forward on the explanatory power of Sharpe's Model. Lorrie and Hamilton [12, p. 207] gave a brief discussion on such evidence. However, Modern Portfolio Theory (and Sharpe's Model) is not without its limitations and arguments. The major controversy centers around the proper measurements of risk, the stabilities of such measures, and their relationships to rate of return. Francis [6, p. 211] is concerned mainly with the question:

"what is the best portfolio risk surrogate?" Portfolio Analysis is based on the assumption that the variance (or standard deviation) of return is the proper surrogate for portfolio risk. However, no conclusive evidence supporting this assumption has been published. Francis has given a detailed description on numerous other intuitively acceptable measures of risk. The stability of risk measures (particularly Betas) has also been studied closely. In general, Betas for individual securities are fairly unstable. Levy [11] and others, however, concluded from their studies that the Betas of (efficient) portfolios are highly stable. This is quite generally accepted, although there are still those who argue against it. Other studies were made on the relationships between the rate of return and Beta. The results are fairly inconclusive. Levy [10], in his recent article, presented his study on whether Beta coefficients are good predictors of return. He confirmed, with some reservations, the hypothesis that returns and Betas are positively correlated during bull markets and negatively correlated during bear markets. Black, Jensen and Scholes [1] also explained the fact that returns are not strictly proportional to Betas. Even with all these controversies, nevertheless, most portfolio theorists and commentators agree that, though imperfect, Betas and related measures of risk are useful to money managers.

Ever since the advent of Sharpe's Model, various suggestions for modifications of the model were put forth. Here we could list a number of them only. Besides the Single-index Model, Sharpe [16, p. 122] has also put forward a "multi-index Model." Thus, instead of relating to only one index, securities are assumed to be related to each other through a number of economic indices. Though the relationships among securities may be better defined, the Multi-index Model has found little use in actual applications. A number of theorists have proposed other modifications to the original model suggested by Sharpe. For example, Fouse, Jahnke and Rosenberg [5] have redefined the characteristic line so that Beta is computed from the following equation instead.

$$\ln (r_{it} - r_{Ft}) = a_i + b_i . \ln(r_{mt} - r_{Ft}), \qquad t = T - 1$$

Black, Jensen, and Schole [1] suggested a model, more complicated than Sharpe's, but not fundamentally different, such that the expected return on an investment is explained by:

$$E(r_i) = E(r_z) . (1 - b_i) + E(I) . b_i ,$$

where r_z is generally known as the Beta factor. Treynor and Black [18], on the other hand, have proceeded to see how Security Analysis can be modified to improve portfolio selections.

As a final remark of our study, Portfolio Theory, though relatively young in its history, has proved its usefulness; and it will not be long when it can be widely accepted by those in the investment circle elsewhere. However, in Hong Kong, it may need to take a longer time.

APPENDICES

APPENDIX A

RISK OF A PORTFOLIO

The risk of a portfolio is given by the variance of the rate of return on the portfolio, i.e.,

$$\begin{aligned}
\sigma_p^2 &= \text{var}(r_p) = E(r_p - E_p)^2 \\
&= E(\sum_{i=1}^{N} X_i . r_i - \sum_{i=1}^{N} X_i . E(r_i))^2 \\
&= E(\sum_{i=1}^{N} X_i . (r_i - E_i))^2 \qquad \text{where } E_i = E(r_i) \\
&= E(\sum_{i=1}^{N}\sum_{j=1}^{N} X_i . X_j . (r_i - E_i).(r_j - E_j)) \\
&= \sum_{i=1}^{N} X_i^2 . E(r_i - E_i)^2 + 2. \sum_{i \gtrless j}^{N}\sum^{N} X_i . X_j . E((r_i - E_i).(r_j - E_j)) \\
&= \sum_{i=1}^{N} X_i^2 . \text{var}(r_i) + 2. \sum_{i \gtrless j}^{N}\sum^{N} X_i . X_j . \text{cov}(r_i, r_j) \\
&= \sum_{i}^{N}\sum_{j}^{N} X_i . X_j . \sigma_{ij} .
\end{aligned}$$

Expressed in matrix form, σ_p^2 is given by

$$\sigma_p^2 = \underline{X}' \, \underline{V} \, \underline{X}$$

where

$$\underline{X}' = (X_1, X_2, \ldots, X_N)$$

$$\underline{V} = \begin{bmatrix} \text{var}(r_1) & \text{cov}(r_1, r_2) & \cdots & \text{cov}(r_1, r_N) \\ \text{cov}(r_2, r_1) & \text{var}(r_2) & & \cdots \\ \cdots & & \cdots & \cdots \\ \text{cov}(r_N, r_1) & \cdots & \cdots & \text{var}(r_N) \end{bmatrix}$$

= covariance matrix of the rates of return of the securities

= (σ_{ij}) where $\sigma_{ij} = \mathrm{cov}(r_i, r_j)$.

APPENDIX B

CALCULATION OF EXPECTED RETURN AND VARIANCE OF RETURN OF THE I TH SECURITY, USING SHARPE'S SINGLE-INDEX MODEL

The return of the ith security for period t is given by

$$r_{it} = a_i + b_i . I_t + e_{it} .$$

Therefore, the expected return of the ith security is

$$\begin{aligned} E(r_i) &= E(a_i + b_i . I_t + e_{it}) \\ &= E(a_i) + E(b_i) . E(I_t) + E(e_{it}) \\ &= a_i + b_i . E(I) + 0 && (E(e_{it}) = 0) \\ &= a_i + b_i . \bar{I} && \text{where } E(I) = \bar{I} . \end{aligned}$$

The variance of return is given by

$$\begin{aligned} var(r_i) &= E(r_i - E(r_i))^2 \\ &= E((a_i + b_i . I + e_i) - (a_i + b_i . \bar{I}))^2 \\ &= E(b_i . (I - \bar{I}) + e_i)^2 \\ &= E(b_i^2 . (I - \bar{I})^2 + 2 . b_i . (I - \bar{I}) . e_i + e_i^2) \\ &= b_i^2 . E(I - \bar{I})^2 + 2 . b_i . (I - \bar{I}) . E(e_i) + E(e_i^2) \\ &= b_i^2 . \ var(I) + var(e_i) && (E(e_i) = 0) \end{aligned}$$

Therefore,

$$E(r_i) = a_i + b_i . \bar{I}$$

$$var(r_i) = b_i^2 . \ var(I) + var(e_i) .$$

APPENDIX C

CALCULATION OF EXPECTED RETURN AND VARIANCE OF RETURN OF AN N-SECURITIES PORTFOLIO, USING SHARPE'S SINGLE-INDEX MODEL

The portfolio's return is given by

$$r_p = \sum_{i=1}^{N} X_i . r_i$$

$$= \sum_{i=1}^{N} X_i . (a_i + b_i . I + e_i)$$

$$= \sum_{i=1}^{N} X_i . (a_i + e_i) + (\sum_{i=1}^{N} X_i . b_i) . I \ .$$

Denoting $X_{N+1} = \sum_{i=1}^{N} X_i . b_i ,$

$$r_p = \sum_{i=1}^{N} X_i . (a_i + e_i) + X_{N+1} . I \ .$$

The <u>expected return</u> on the portfolio is

$$E_p = E(r_p)$$

$$= \sum_{i=1}^{N} X_i . a_i + X_{N+1} . E(I) \qquad (E(e_i) = 0).$$

Denoting $a_{N+1} = E(I),$

$$E_p = \sum_{i=1}^{N+1} X_i . a_i \ .$$

The <u>variance of return</u> of the portfolio is given by

$$\sigma_p^2 = var(r_p)$$

$$= E(r_p - E_p)^2$$

$$= E(\sum_{i=1}^{N} X_i . e_i + X_{N+1} . (I - E(I)))^2$$

$$= E((\sum_{i=1}^{N} X_i . e_i)^2 + 2 . X_{N+1} . (I - E(I)) . (\sum_{i=1}^{N} X_i . e_i) +$$

$$X_{N+1}^2 . (I - E(I))^2)$$

$$= \sum_{i=1}^{N} X_i^{\,2}.E(e_i^{\,2}) + X_{N+1}^{\,2}.E(I - E(I))^2 \qquad (E(e_i\ e_j) = 0,\ i \neq j)$$

$$= \sum_{i=1}^{N} X_i^{\,2}.\ var(e_i) + X_{N+1}^{\,2}.var(I) \qquad (\ var(e_i) = E(e_i^{\,2}).$$

Denoting $var(e_{N+1}) = var(I)$,

$$\sigma_p^{\,2} = \sum_{i=1}^{N+1} X_i^{\,2}.\ var(e_i)\ .$$

APPENDIX D

CALCULATION OF ALPHA AND BETA COEFFICIENTS OF THE REGRESSION

LINE $r_i = a_i + b_i.I_t$ USING THE LEAST-SQUARE METHOD

The principle of the Least-square method is to minimize the quantity $\sum_{t=1}^{m} e_{it}^2$. Remembering

$$e_{it} = r_{it} - a_i - b_i.I_t$$

then

$$\sum_{t=1}^{m} e_{it}^2 = \sum_{t=1}^{m} (r_{it} - a_i - b_i.I_t)^2.$$

To minimize this quantity, differentiate with respect to a_i and b_i and set to zero.

$$\frac{\partial}{\partial a_i} (\sum_{t=1}^{m} e_{it}^2) = -2.\sum_{t=1}^{m} (r_{it} - a_i - b_i.I_t) = 0, \text{ and}$$

$$\frac{\partial}{\partial b_i} (\sum_{t=1}^{m} e_{it}^2) = -2.\sum_{t=1}^{m} I_t.(r_{it} - a_i - b_i.I_t) = 0.$$

Note that the first equation requires $\sum_{t=1}^{m} e_{it} = 0$. The two equations are equivalent to the following :

$$b_i.\sum_{t}^{m} I_t + a_i.m - \sum_{t}^{m} r_{it} = 0, \text{ and}$$

$$b_i.\sum_{t}^{m} I_t^2 + a_i.\sum_{t}^{m} I_t - \sum_{t}^{m} r_{it}.I_t = 0.$$

These give

$$b_i = \frac{\sum_{t}^{m} I_t.\sum_{t}^{m} r_{it} - m.\sum_{t}^{m} r_{it}.I_t}{(\sum_{t}^{m} I_t)^2 - m.\sum_{t}^{m} I_t^2}$$

$$= \frac{\frac{1}{m} \cdot (\sum_{t}^{m} r_{it} \cdot I_t) - (\frac{1}{m} \sum_{t}^{m} I_t) \cdot (\frac{1}{m} \sum_{t}^{m} r_{it})}{\frac{1}{m} \cdot (\sum_{t}^{m} I_t^2) - (\frac{1}{m} \sum_{t}^{m} I_t)^2}$$

Therefore,

$$b_i = \frac{\mathrm{cov}(r_i, I)}{\mathrm{var}(I)} .$$

Also since

$$\bar{r}_i - a_i - b_i . \bar{I} = 0$$

therefore,

$$a_i = \bar{r}_i - b_i . \bar{I}$$

$$= \bar{r}_i - \frac{\mathrm{cov}(r_i, I)}{\mathrm{var}(I)} . \bar{I} .$$

Hence, the regression line becomes

$$r_i = (\bar{r}_i - \frac{\mathrm{cov}(r_i, I)}{\mathrm{var}(I)} . \bar{I}) + \frac{\mathrm{cov}(r_i, I)}{\mathrm{var}(I)} . I,$$

or simply,

$$r_i - \bar{r}_i = \frac{\mathrm{cov}(r_i, I)}{\mathrm{var}(I)} . (I - \bar{I}).$$

APPENDIX E

SOURCE PROGRAM I FOR GENERATING STATISTICAL INPUTS

PORTFOLIO ANALYSIS FOR SELECTED HONG KONG SECURITIES -- SOURCE PROGRAM 1

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                              C
C       THIS PROGRAM READS IN THE MARKET PRICES, DIVIDEND PAYMENTS     C
C       AND MARKET INDICES AT VARIOUS TIME INTERVALS FOR A SPECIFIED   C
C       PERIOD OF TIME;  IT THEN COMPUTES ALL THE NECESSARY VARIABLES  C
C       AND LIST ALL RELEVANT RESULTS AND CHARTS                       C
C       PROGRAMMED BY ALEX LAM           DECEMBER 1973                 C
C                                                              C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
```

```
                  ------------------------------
                  I                            I
                  I         M A S T E R        I
                  I                            I
                  ------------------------------
```

```
      MASTER ALEX
C
      DIMENSION ROR(50), AINDEX(50), NAMSEC(16), NAMABB(3)
      DIMENSION DIVIDD(4), GWRATE(50), PERIOD(50)
      DIMENSION YEAR(24), XDUMMY(50), YDUMMY(50)
      DIMENSION INDSTY(24)
      COMMON /DUST/INDSTY
      DATA YEAR/6H68    I, 6H68   II, 6H68 III, 6H68  IV,
     *          6H69    I, 6H69   II, 6H69 III, 6H69  IV,
     *          6H70    I, 6H70   II, 6H70 III, 6H70  IV,
     *          6H71    I, 6H71   II, 6H71 III, 6H71  IV,
     *          6H72    I, 6H72   II, 6H72 III, 6H72  IV,
     *          6H73    I, 6H73   II, 6H73 III, 6H73  IV/
C
C       DIVIDD(1) = STOCK SPLIT ( EXPRESSED AS PER SHARE VALUES)
C       DIVIDD(2) = STOCK DIVIDEND (EXPRESSED AS PER SHARE VALUES)
C       DIVIDD(3) = CASH DIVIDEND ($)
C       DIVIDD(4) = LIQUIDATION VALUE OF PROPERTY DIVIDEND,
C                   RIGHT OFFERED, ETC.
C
      READ(1, 10) NPERID
      READ(1, 20) MSINDX
C
      WRITE(3, 80)
      AVINDX = 0.
      YMAX   = 0.
C
      DO 100 I = 1, NPERID
      DENOMT = HSINDX
      ADUMMY    = I
```

CONTINUED ON NEXT PAGE

```
      PERIOD(I) = 67.75 + ADUMMY/4.
      READ(1, 20) HSINDX
      YDUMMY(I) = HSINDX
      XDUMMY(I) = PERIOD(I)
      AINDEX(I) = (HSINDX - DENOMT) / DENOMT
      IF (HSINDX .GT. YMAX) YMAX = HSINDX
      WRITE(3, 81) I, YEAR(I), HSINDX, AINDEX(I)
      AVINDX = AVINDX + AINDEX(I)
      WRITE(4, 21) I, HSINDX, AINDEX(I)
  100 CONTINUE
C
      WRITE(3, 70)
      AVINDX = AVINDX / NPERID
C
      VARIND = 0.
      DO 110 I = 1, NPERID
      VARIND = VARIND + (AINDEX(I) - AVINDX) ** 2
  110 CONTINUE
      VARIND = VARIND / (NPERID - 1)
      WRITE(3, 82) AVINDX, VARIND
C
C
      WRITE(7, 75)
      CALL PPLOT(XDUMMY,YDUMMY,NPERID,78.,68.,YMAX,0.,0,0, 7)
C
      CALL RPLACE(PERIOD, AINDEX, XDUMMY, YDUMMY, NPERID)
      WRITE(7, 73)
      XMAX   = 78.
      XMIN   = 68.
      YMAX   = 0.90
      YMIN   = -0.60
      CALL PPLOT(XDUMMY,YDUMMY,NPERID,XMAX,XMIN,YMAX,YMIN,0, 0, 7)
C
      READ(5, 10) NUMSEC
      WRITE(6, 10) NUMSEC
      READ (5, 11) INDSTY
      WRITE(4, 12) INDSTY
C
      WRITE(8, 71)
      WRITE(9, 72)
      WRITE(10, 74)
C
C
C
      DO 1000 II = 1, NUMSEC
      READ(5, 30) NAMSEC, NAMABB, INDUST, NUMBER
C     IF (II .NE. NUMBER) CALL ERROR(1)
C
      CALL HEADING(    II, NAMSEC, NAMABB, INDUST)
C
      WRITE(4, 30) NAMSEC, NAMABB, INDUST, II
      READ(5, 20) PRICE , DIVIDD
```

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```
      WRITE(4, 20) PRICE , DIVIDD
C
      STOKNO = 1.
C
C       STOKNO IS THE TOTAL NUMBER OF STOCKS POSSESSED AFTER THE WHOLE
C       PERIOD GIVEN ONE STOCK AT THE BEGINNING OF THE PERIOD
C
      DO 200 I = 1, NPERID
      DENOPR = PRICE
      READ(5, 20) PRICE, DIVIDD
      WRITE(4, 20) PRICE , DIVIDD
      IF (DIVIDD(1) .EQ. 0.) DIVIDD(1) = 1.
      IF (DIVIDD(1) .LT. 1.) CALL ERROR(2)
      ROR(I) = ( PRICE * (1. + DIVIDD(2))   *  DIVIDD(1) + DIVIDD(3) +
     *            DIVIDD(4) - DENOPR )   /   DENOPR
      WRITE(3,60) I, YEAR(I), PRICE, DIVIDD, ROR(I)
      STOKNO = STOKNO * (1. + DIVIDD(2)) * DIVIDD(1)
      YDUMMY(I) = PRICE
      IF (I .NE. 1) GO TO 190
      XDUMMY(1) = 1.
      GO TO 200
  190 XDUMMY(I) = XDUMMY(I-1) * (1. + DIVIDD(2)) * DIVIDD(1)
  200 CONTINUE
      WRITE(3, 70)
C
C       YDUMMY, THE ADJUSTED PRICE, IS TO BE CONSTRUCTED
C
      DO 210 I = 1, NPERID
      YDUMMY(I) = YDUMMY(I) * XDUMMY(I) / STOKNO
      XDUMMY(I) = PERIOD(I)
  210 CONTINUE
C
      YMAX    = 0.
      DO 220 I = 1, NPERID
  220 IF (YDUMMY(I) .GT. YMAX) YMAX = YDUMMY(I)
      CALL PPLOT(XDUMMY,YDUMMY,NPERID,78.,68.,YMAX,0.00,0 ,II,10)
      WRITE(10, 50) NAMSEC
C
C
C
      CALL RPLACE(PERIOD, ROR, XDUMMY, YDUMMY, NPERID)
      XMAX    = 78.
      XMIN    = 68.
      YMAX    = 2.33333333
      YMIN    = -1.00
      CALL PPLOT(XDUMMY,YDUMMY,NPERID,XMAX,XMIN,YMAX,YMIN,0,II, 8)
      WRITE(8, 50) NAMSEC
C
      CALL RPLACE(AINDEX, ROR, XDUMMY, YDUMMY, NPERID)
      XMAX    = 1.40
      XMIN    = -0.60
      YMAX    = 2.33333333
```

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```
      YMIN    = -1.00
      CALL PPLOT(XDUMMY,YDUMMY,NPERID,XMAX,XMIN,YMAX,YMIN,0,II,9)
      WRITE(9, 50) NAMSEC
C
C
      EXPROR = 0.
C
      DO 300 I = 1, NPERID
      EXPROR = EXPROR + ROR(I)
  300 CONTINUE
C
      EXPROR = EXPROR / NPERID
C
      VARROR = 0.
      SUM    = 0.
C
      DO 400 I =1, NPERID
      VARROR = VARROR + (ROR(I) - EXPROR) ** 2
      SUM    = SUM + (AINDEX(I) - AVINDX) * (ROR(I) - EXPROR)
  400 CONTINUE
C
      BETA = SUM /((NPERID - 1) * VARIND )
      VARROR = VARROR / (NPERID - 1)
      AVALUE = EXPROR - BETA * AVINDX
      SDROR  = SQRT(VARROR)
C
      WRITE(3, 65) EXPROR, VARROR, SDROR, AVALUE, BETA
C
      VARERR = VARROR- VARIND * (BETA ** 2)
C
      WRITE(6, 30) NAMSEC, NAMABB, INDUST, II
      WRITE(6, 40) EXPROR, VARERR, BETA, AVALUE
 1000 CONTINUE
C
C
C
      WRITE(6, 40) VARIND
C
   10 FORMAT(8I10)
   11 FORMAT(10A8)
   12 FORMAT(1H , 10A8)
   20 FORMAT(8F10.4)
   21 FORMAT(1H , I10,6F10.4)
   30 FORMAT(16A4, 1X, 2A4, A2, I2, 1X, I2)
   40 FORMAT(6F20.8)
   50 FORMAT(1H , 16A4, 1X, 2A4, A2, I2, 1X, I2)
   60 FORMAT(1H , 2X, I2, 4X, A6, 2X, F6.2, 3(2X, F5.2), 4X, F5.2,
     * 5X, F10.4)
   65 FORMAT(1H0, 10X, 'AVERAGE RETURN', 13X, ':', 10X, F10.4/
     *        1H0, 10X, 'VARIANCE OF RETURN', 9X, ':', 10X, F10.4/
     *        1H0, 10X, 'STANDARD DEVIATION', 9X, ':', 10X, F10.4/
     *        1H0, 10X, 'ALPHA COEFFICIENT', 10X,    ':', 10X, F10.4/
```

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```
     *        1H0, 10X, 'BETA COEFFICIENT', 11X,      ':', 10X, F10.4/)
  70 FORMAT(1H0,      72(1H-))
  71 FORMAT(1H1//////////1H0, 10X, 'PLOT OF RATE OF RETURN ON INVESTMEN
     *T AGAINST TIME '/)
  72 FORMAT(1H1//////////1H0, 10X, 'PLOT OF RATE OF RETURN AGAINST RATE
     * OF CHANGE OF MARKET INDEX'/)
  73 FORMAT(1H1, 10X, 'PLOT OF RATE OF CHANGE OF MARKET INDEX AGAINST T
     *IME'/)
  74 FORMAT(1H1//////////1H0, 10X, 'PLOT OF MARKET PRICE (ADJUSTED) AGA
     *INST TIME'/)
  75 FORMAT(1H1,              10X, 'PLOT OF MARKET INDEX AGAINST TIME'/)
  80 FORMAT(1H1////1H , 25X, 'HANG SENG MARKET INDEX'///
     *                1H , 72(1H-)/
     *                1H , 2X, 'PERIOD', 2X, 'QUARTER YEAR', 6X,
     * 'HANG SENG INDEX', 4X, 'RATE OF CHANGE OF INDEX', 3X, /
     *                1H , 72(1H-)//)
  81 FORMAT(1H , 4X, I2, 7X, A6, 12X, F7.2, 16X, F8.4)
  82 FORMAT(1H //1H0, 10X, 'AVERAGE RATE OF CHANGE', 8X, ':', 10X,F10.4
     *             /1H0, 10X, 'VARIANCE OF RATE OF CHANGE', 4X, ':', 10X,
     *                  F10.4/)
C
      STOP
      END


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      SUBROUTINE RPLACE(X, Y, A, B, N)
C
C       THIS SUBROUTINE REPLACES THE X AND Y ARRAYS BY A AND B ARRAYS
C
      DIMENSION A(50), B(50)
      DIMENSION X(50), Y(50)
C
      DO 100 I = 1, N
      A(I) = X(I)
      B(I) = Y(I)
 100  CONTINUE
C
      RETURN
      END
```

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                  ------------------------------


      SUBROUTINE HEADING(N, NA, NAB, IN)
C
C       THIS SUBROUTINE WRITES OUT HEADINGS FOR SOME LISTINGS
C
      DIMENSION NA(16), NAB(3)
      DIMENSION INDSTY(24)
      COMMON /DUST/INDSTY
C
      WRITE(3, 10) NA, N,NAB, INDSTY(2*IN-1),INDSTY(2*IN)
      WRITE(3, 20)
      WRITE(3, 30)
      WRITE(3, 20)
C
   10 FORMAT(1H1///1H , 16A4, 5X, I2//
     *                 1H , 2A4, A2, 10X, 2A8//)
   20 FORMAT(1H ,      72(1H-)/)
   30 FORMAT(1H , 7X, 'QUARTER', 2X, 'MARKET', 2X, 'STOCK', 2X,'STOCK',
     * 2X, 'CASH', 3X, 'PROP DIV OR',3X, 'RETURN ON'/
     * 1H , 'PERIOD', 1X, 'YEARLY', 3X, 'PRICE', 3X, 'SPLIT', 2X, 'DIVID
     *', 2X, 'DIVID', 2X, 'RTS ISSUED', 3X, 'INVESTMENT'/
     * 1H , 18X, '($)', 18X, '($)', 6X, '($)'/)
C
      RETURN
      END


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      SUBROUTINE PPLOT(X,Y,N,XMAX,XMIN,YMAX,YMIN,KEY,ITITLE,L)
C
C       THIS SUBROUTINE PLOTS OUT THE X &  Y  ARRAYS
C       ALONG THE X- AND Y- AXES
C
      INTEGER CHAR,GRID1,GRID2
      DIMENSION X(N),Y(N),LINE(101),XV(6 )
      DIMENSION GRID1(2),GRID2(2)
      DATA CHAR/1H*/,GRID1/1H ,1H-/,GRID2/1HI,1H+/
```

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PORTFOLIO ANALYSIS FOR SELECTED HONG KONG SECURITIES -- SOURCE PROGRAM 1

```
C     ARRANGE IN DESCENDING ORDER OF Y
      DO 10 I=1,N
      DO 10 J=I,N
      IF (Y(J).LE.Y(I)) GO TO 10
      TEMP=Y(J)
      Y(J)=Y(I)
      Y(I)=TEMP
      TEMP=X(J)
      X(J)=X(I)
      X(I)=TEMP
   10 CONTINUE
      IF (KEY.EQ.0) GO TO 19
      YMAX=Y(1)
      YMIN=Y(N)
      XMAX=X(1)
      XMIN=X(1)
      DO 3 I=2,N
      IF (X(I).GT.XMAX) XMAX=X(I)
      IF (X(I).LT.XMIN) XMIN=X(I)
    3 CONTINUE
C     SETTING UP SCALES
   19 XSCALE=(XMAX-XMIN)/100.0
      YSCALE=(YMAX-YMIN)/50.0
      LCOUNT=5
      IF (ITITLE.EQ.0) GO TO 20
      WRITE (L,21)ITITLE
   21 FORMAT (1H1,45X,7HFIGURE ,I4/)
   20 XG=XMIN-XSCALE/2.0
      YG=YMAX-YSCALE/2.0
      YV=YMAX
      J=1
      IC=1
      DO 30 I=1,51
      IF(LCOUNT.EQ.5) IC=2
      LL=10
      DO 40 K=1,101
      IF (LL.LT.10) GO TO 46
      LINE(K)=GRID2(IC)
      LL=1
      GO TO 40
   46 LL=LL+1
      LINE(K)=GRID1(IC)
   40 CONTINUE
   50 IF (J.GT.N) GO TO 29
      IF (Y(J).LT.YG) GO TO 60
      MX=(X(J)-XG   )/XSCALE+1
      IF (MX.LT.1) MX=1
      IF (MX.GT.101) MX=101
      LINE(MX)=CHAR
      J=J+1
      GO TO 50
   60 YG=YG-YSCALE
```

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```
   29 IF (LCOUNT.LT.5) GO TO 70
      IC=1
      LCOUNT=1
      WRITE (L,80)YV,LINE
80    FORMAT (1H ,F11.4  ,101A1)
      YV=YV-5.0*YSCALE
      GO TO 30
   70 WRITE (L,81)LINE
   81 FORMAT (12X,101A1)
      LCOUNT=LCOUNT+1
   30 CONTINUE
      XV(1)=XMIN
      DO 90 I=2,6
90    XV(I)=XV(I-1)+XSCALE*20.0
      WRITE (L,91) XV
91    FORMAT (1H ,6(9X,1PG11.4))
      RETURN
      END
```

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                   I                            I
                   I     S U B R O U T I N E    I
                   I                            I
                   ------------------------------
```

```
      SUBROUTINE ERROR(K)
C
C       THIS IS AN ERROR SUBROUTINE WHICH WILL STOP THE PROGRAM
C       WHENEVER ERROR IS DETECTED
C
C
      DIMENSION ERRAR(10)
      DATA ERRAR(1)/6HERROR1/
      DATA ERRAR(2)/6HERROR2/
      DATA ERRAR(3)/6HERROR3/
C
      WRITE(2, 10) ERRAR(K)
   10 FORMAT(1H1, A6)
C
      STOP
      END
      FINISH
```

END OF PROGRAM

APPENDIX F

SOURCE PROGRAM II FOR SOLVING THE BASIC PROBLEM OF PORTFOLIO ANALYSIS

PORTFOLIO ANALYSIS FOR SELECTED HONG KONG SECURITIES -- SOURCE PROGRAM 2

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                      C
C                                                                      C
C       THIS PROGRAM ATTEMPTS TO SOLVE A PARTICULAR QUADRATIC          C
C       PROGRAMMING PROBLEM OF THE FORM                                C
C                                                                      C
C                                          MAX Z = TCX - XDX       (#) C
C       SUBJECT TO THE CONTRAINTS          SUM X = 1 ,                 C
C                                 SUM (BETA * X) = X(N+1)              C
C                                              X > 0 OR = 0, AND       C
C                                              T > 0 OR = 0            C
C                                                                      C
C       ( D IS A DIAGONAL MATRIX )                                     C
C       THIS PROBLEM CAN BE REDUCED TO A LINEAR PROGRAMMING            C
C       OF THE FORM                                                    C
C                                                                      C
C                                          MAX Z = - SUM U         (*) C
C       SUBJECT TO THE CONSTRAINT             QW = F                   C
C                                              W > OR = 0              C
C                                             XV = 0                   C
C                                                                      C
C       READERS ARE ADVISED TO REFER TO HADLEY'S                       C
C       ' NON-LINEAR AND DYNAMIC PROGRAMMING '                         C
C                                                                      C
C       THE NUMBER OF SECURITIES SHOULD NOT EXCEED 20                  C
C                                                                      C
C       PROGRAMMED BY ALEX LAM           NOVEMBER 1973                 C
C                                                                      C
C                                                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC


                    ----------------------------
                    I                          I
                    I      M A S T E R         I
                    I                          I
                    ----------------------------


      MASTER ALEX
C
C
C
C        NUMSEC = NUMBER OF SECURITIES  IN THE SELECTED PORTFOLIO
C        NUMSECAD = TOTAL NUMBER OF  'X'  VARIABLES
C                   (= NUMSEC + 1)
C        QMAT = THE NEW CONSTRAINT MATRIX IN QW = F
C               DIM : (NRQMAT, NCQMAT)
C               NRQMAT = NUMSEC + 3
C               NCQMAT = 7 + 3 * NUMSEC
```

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PORTFOLIO ANALYSIS FOR SELECTED HONG KONG SECURITIES -- SOURCE PROGRAM 2

```
C       CMAT = CONTAINS COEFFICIENTS OF THE LINEAR FORM OF  'X'
C       C    = A COLUMN VECTOR OF COEFFICIENTS OF THE LINEAR FORM
C              OF ' X ', ADJUSTED BY THE RISK PREFERENCE  'THETA'
C              DIM : (1, NUMSECAD)
C       BETA = BETA COEFFICIENTS OF ALL THE SECURTIES
C       DMAT = A 'DIAGONAL' MATRIX CONTAINING COEFFICENTS OF THE
C              QUADRATIC FORM OF ' X '
C              DIM : (NUMSECAD, NUMSECAD)
C       BMAT = BASIC MATRIX TO THE CONSTRAINTS OF  (#)
C       XBMAT= BASIC SOLUTION WITH RESPECT TO BMAT OF  (#)
C       EMAT = MATRIX OF THE ARTIFICIAL VARIABLES 'U'
C              DIM : (NUMSECAD, NUMSECAD)
C       LABR = VALUES OF SUBSCRIPTS OF THE VARIABLES IN 'QBMAT'
C       CBMAT = COEFFICIENTS OF THE OBJECTIVE FUNCTION  Z = -  SUM U
C               DIM :  (NUMSEC + 3)
C       BBQMAT = REVISED FORM OF THE BASIC MATRIX TO THE CONSTRAINT
C                QW = E
C                DIM : (NRBBQMAT, NCBBQMAT)
C                NRBBQMAT = NCBBQMAT = NUMSEC + 4
C       QBMAT  = BASIC SOLUTION WITH RESPECT TO BBQMAT, A COLUMN VECTOR
C                DIM : (NRBBQMAT,1)
C       YSUBK  = A COLUMN VECTOR CONTAINING VALUES OF COEFFICIENTS OF
C                'K' TH PIVOTOL  COLUMN OF THE MATRIX 'QMAT';
C                THE PIVOTOL COLUMN IS TO BE REMOVED
C                DIM : (NRBBQMAT, 1)
C       ROR    = EXPECTED RETURN OF THE EFFICIENT PORTFOLIO, FOR A
C                GIVEN VALUE OF  'THETA'
C       VARROR = VARIANCE OF RETURN OF THE EFFICIENT PORTFOLIO, FOR A
C                GIVEN VALUE  'THETA'
C
      DIMENSION  QMAT(23, 67)
      DIMENSION  C(1, 21), DMAT(21, 21)
      DIMENSION  CMAT(21)
      DIMENSION  AMAT(2, 21), BMAT(2, 2), XBMAT(2)
      DIMENSION  EMAT(21, 21), UMAT(21)
      DIMENSION  BBQMAT(24, 24)
      DIMENSION  QBMAT(24, 1), LABR(23), CBMAT(24)
      DIMENSION  YSUBK(24, 1), TEST(24)
      DIMENSION TABLEA(24, 25)
      DIMENSION  BETA(21)
      DIMENSION  THETA(50)
      DIMENSION  XDUMMY(50), YDUMMY(50)
      DIMENSION  ROR(50), VARROR(50), SDROR(50)
      DIMENSION  OQBMAT(21, 50)
      DIMENSION  NAMSEC(16), NAMABR(3)
      DOUBLE PRECISION QMAT, C, DMAT, CMAT, AMAT, BMAT, XBMAT, EMAT, UMA
     *T, BBQMAT, QBMAT, CBMAT, YSUBK, TABLEA, TEMP, TEST, THETA, BETA,
     *OQBMAT
      DOUBLE PRECISION D1, D2
      COMMON/ATHET/THETA, NTHETA
      COMMON  /CONBER/ ROR, VARROR, SDROR, OQBMAT
      DATA  LANK/8H        /
```

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PORTFOLIO ANALYSIS FOR SELECTED HONG KONG SECURITIES -- SOURCE PROGRAM 2

```
      EQUIVALENCE (TABLEA(1,1), BBQMAT(1,2))
      EQUIVALENCE  (NRQMAT, NRBQMAT, NCBQMAT)
      EQUIVALENCE  (NRBBQMAT, NCBBQMAT)
      EQUIVALENCE  (QBMAT(4, 1), UMAT(1))
C
C
C        READ IN DATA AND PRINT OUT
C
      READ(5, 20) D1, D2
      READ(1, 10) NUMSEC
C
      NCQMAT = 7 + 3*NUMSEC
      NRQMAT = NUMSEC + 3
      NRBBQMAT = NUMSEC + 4
      NUMSECAD = NUMSEC + 1
C
      DO 100 I =1, NUMSEC
      READ(1, 19) NAMSEC, NAMABB, INDUST, II
      IF (II .NE. I) CALL ERROR(3)
      READ(1, 20) CMAT(I), DMAT(I, I), BETA(I)
      DMAT(I, I) = -DMAT(I, I)
  100 CONTINUE
      CMAT(NUMSECAD) = 0.
      READ(1, 20) VARIND
      DMAT(NUMSECAD, NUMSECAD) = -VARIND
      WRITE(2, 40) (CMAT(I), I =1, NUMSECAD)
      CALL MATOUT(DMAT, NUMSECAD, NUMSECAD, 21, 21, 2, 0)
C
      BETA(NUMSEC + 1) = -1.
      WRITE(2, 40)(BETA(I), I=1, NUMSECAD)
C
C
C        INITIALIZE BMAT AND AMAT
C
      DO 200 I = 1, NUMSECAD
      AMAT(1, I) = 1.
      AMAT(2, I) = BETA(I)
  200 CONTINUE
      AMAT(1, NUMSECAD) = 0.
      BMAT(1, 1) = 1.
      BMAT(1, 2) = 0.
      BMAT(2, 1) = BETA(1)
      BMAT(2, 2) = -1.
C
      NTHETA = 0
C
C
C
C
C        FOR EACH VALUE OF NTHETA, A NEW VALUE OF THETA IS READ IN:
C        THE QUADRATIC PROGRAMMING PROBLEM IS SOLVED TO YIELD THE
C        REQUIRED VALUES OF QBMAT, ROR, AND VARROR.
```

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```
C        AT THE END OF THE FILE OF THETA, GO TO 2000
C
C

 8888 CONTINUE
C
      XBMAT(1) = 1.
      XBMAT(2) = BETA(1)
C
C        THETA IS THE PREFERENCE OF ROR OVER RISK BY THE INVESTOR
C        THETA >  OR  = 0
C
      NTHETA = NTHETA + 1
      READ(3, 20, END=2000) THETA(NTHETA)
C
C        REVISE VALUES OF CMAT BY THETA
C
      DO 230 I = 1, NUMSECAD
  230 C(1, I) = THETA(NTHETA) * CMAT(I)
C
C
      WRITE(2, 9)
      WRITE(2, 50) NTHETA, THETA(NTHETA)
C
C
C        CONSTRUCT 'EMAT'
C
      DO 300 I = 1, NUMSECAD
      DO 300 J =1, NUMSECAD
      EMAT(I, J) = 0.
      YDUM = -C(1, I) - 2. *
     *     (DMAT(I, 1) * XBMAT(1) + DMAT(I, 2) *  XBMAT(2))
      IF (YDUM.GE.0.) GO TO 350
      EMAT(I, I) = -1.
      GO TO 300
  350 EMAT(I, I) =  1.
  300 CONTINUE
C
C
C     CALL MATOUT (EMAT, NUMSECAD, NUMSECAD, 21, 21, 3)
C
C        CONSTRUCT 'QMAT'
C
      DO 500 J=1, NCQMAT
      QMAT(NRQMAT,J) = 0.
      QMAT(NRQMAT-1, J) = 0.
      DO 500 I =1, NUMSECAD
      QMAT(I, J) = 0.
      QMAT(1, I) = AMAT(1, I)
      QMAT(2, I) = AMAT(2, I)
      QMAT(I+2, I) = 2. * DMAT(I, I)
```

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```
      QMAT(I+2, NUMSEC+2) = -AMAT(1, I)
      QMAT(I+2, NUMSEC+3) = -AMAT(2, I)
      QMAT(I+2, NUMSEC+4) = AMAT(1, I)
      QMAT(I+2, NUMSEC+5) = AMAT(2, I)
      QMAT(I+2, NUMSEC+5+I) = 1.
      QMAT(I+2, 2*NUMSEC+6+I) = EMAT(I,I)
  500 CONTINUE
C
C     CALL MATOUT(QMAT, NRQMAT, NCQMAT, 23, 67, 4)
C
C
C        INITIALIZE 'UMAT' AND FILL IN 'LABR'
C
      LABR(1) = 1
      LABR(2) = NUMSECAD
      DO 700 I =1, NUMSECAD
      UMAT(I) = EMAT(I,I) * (-C(1, I) -
     *          2. * (DMAT(I, 1) * XBMAT(1) + DMAT(I, 2) * XBMAT(2)))
      LABR(I+2) = 6 + 2*NUMSEC + I
  700 CONTINUE
C
C        CONSTRUCT 'CBMAT', COEFFICIENTS OF THE OBJECTIVE FUNCTION
C        Z = - SUM U
C
      CBMAT(1) = 0.
      CBMAT(2) = 0.
      DO 800 I= 3, NROMAT
  800 CBMAT(I) = -1.
C
C        INITIALIZE 'QBMAT', BASIC SOLUTION TO  (*) WITH RESPECT TO
C        THE INVERSE OF BASIC MATRIX  'BQMAT '
C
      QBMAT(2, 1) = 1.
      QBMAT(3, 1) = BETA(1)
      QBMAT(1, 1) = 0.
      DO 900 I =1, NUMSECAD
  900 QBMAT(1, 1) = QBMAT(1, 1) + CBMAT(I+2) * UMAT(I)
C
C     CALL SOLUTION (NUMSECAD, QBMAT, NRBBQMAT,1, 24,1, LABR, 23)
C
C        CONSTRUCT 'BBQMAT'
C
      DO 950 I=1,NRBBQMAT
      DO 950 J=1, NCBBQMAT
  950 BBQMAT(I, J) = 0.
      BBQMAT(1, 1) =1.
      BBQMAT(2, 2) =  1.
      BBQMAT(2, 3) =  0.
      BBQMAT(3, 2) =  BETA(1)
      BBQMAT(3, 3) = -1.
C
      BBQMAT( 4, 2) = -2. * EMAT(1, 1) *(DMAT(1,1) * BBQMAT(2, 2))
```

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```
      BBQMAT(  5, 3) = -2. * EMAT(2, 2) *(DMAT(2, 2) * BBQMAT(3, 3))
      DO 1050 I = 1, NUMSECAD
      BBQMAT(I+3, I+3) = EMAT(I, I)
 1050 CONTINUE
      DO 1000 I= 2, NRBBQMAT
      BBQMAT(1, I) = 0.
      DO 1000 J=1, NRQMAT
      BBQMAT(1, I) = BBQMAT(1, I) + CBMAT(J) * BBQMAT(J+1, I)
 1000 CONTINUE
C
C     CALL MATOUT(BBQMAT, NRBBQMAT, NCBBQMAT, 24, 24, 6)
C


C
C        ITERATIONS BEGIN FROM HERE
C
       ITERAT = 0
C
C        ITERATIONS CONTINUE UNTIL THE OPTIMUM POINT IS REACHED
C        THAT IS, WHEN QBMAT(1, 1) IS GREATER OR EQUAL TO ZERO;
C        IT WILL THEN GO TO 1500 FOR PRINTING OUT
C
C

 9999 TEMP = 0.
      ITERAT = ITERAT + 1
      IF (ITERAT .LT. 6*NUMSEC) GO TO 1119
      CALL ERROR(1)
 1119 CONTINUE
C1119 WRITE(2, 30) ITERAT
C
C        TO DETERMINE JPIV, THE VECTOR WHICH IS TO GO INTO THE BASIS
C        SUBJECT TO  XV = 0
C
      MDUM = 2*NUMSEC + 6
C
      DO 1100 J = 1, MDUM
      DO 1120 I= 1, NRQMAT
 1120 IF (LABR(I) .EQ. J) GO TO 1100
C
C        CHECK THE CONDITION OF XV =0
C
      NDUM = 0
      VDUM = 0.
      IF (J .GT. NUMSECAD) GO TO 1149
C
C        CHECK THE CASE WHEN 'V' IS THE BASIS
C
      NDUM = NUMSEC + 5 + J
      DO 1140 I= 1, NRQMAT
 1140 IF (LABR(I) .EQ. NDUM .AND. QBMAT(I+1, 1).NE. 0.) GO TO 1100
```

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```
      GO TO 1159
 1149 IF (J .GT. 2*NUMSEC+6 .OR. J .LE. NUMSEC+5) GO TO 1159
C
C        CHECK THE CASE WHEN 'X' IS IN THE BASIS
C
      NDUM = J - NUMSEC - 5
      DO 1150 I=1, NRQMAT
 1150 IF (LABR(I) .EQ. NDUM .AND. QBMAT(I+1, 1) .NE. 0.) GO TO 1100
C
C        DETERMINATION OF JPIV, THE 'PIVOTOL ROW'
C
 1159 DO 1160 K =1, NRQMAT
 1160 YDUM = YDUM + BBQMAT(1, K+1) * QMAT(K, J)
      IF (YDUM.GE.0. .OR. YDUM .GE. TEMP) GO TO 1100
      JPIV = J
      TEMP = YDUM
 1100 CONTINUE
C
C        JPIV IS TO GO TO THE BASIS
C
C
C        DETERMINATION OF 'YSUBK' CORRESPONDING TO JPIV
C
      DO 1200 I=1, NRBBQMAT
      YSUBK(I, 1) =0.
      DO 1200 J=1, NRQMAT
      YSUBK(I, 1) = YSUBK(I, 1) + BBQMAT(I,J+1)*QMAT(J, JPIV)
 1200 CONTINUE
C
C     CALL MATOUT(YSUBK, NRBBQMAT, 1, 24, 1, 7)
C
C        DETERMINATION OF IPIV, THE VECTOR TO BE REMOVED FROM THE BASIS
C
      DO 1300 I=1, NRBBQMAT
      TEST(I) = 9999999.9E30
      IF (YSUBK(I, 1) .LE.   0.1   ) GOTO 1300
      TEST(I) = QBMAT(I, 1) / YSUBK(I, 1)
 1300 CONTINUE
C
      TEMP = 9999999.0E30
      DO 1350 I=1, NRBBQMAT
      IF (TEST(I) .GT. TEMP) GO TO  1350
      IF (TEST(I) .LT. TEMP) GO TO 1349
      IF (YSUBK(I, 1) .LE. YDUM) GO TO 1350
 1349 YDUM = YSUBK(I, 1)
      TEMP = TEST(I)
      IPIV = I-1
      IPIVDU = I
 1350 CONTINUE
C
C        THE 'IPIVDU' TH PIVOTOL COLUMN OF BBQMAT IS TO BE TRANSFORMED
C
```

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PORTFOLIO ANALYSIS FOR SELECTED HONG KONG SECURITIES -- SOURCE PROGRAM 2

```
C
C      UPDATE VALUES IN 'LABR'
C
      LABR(IPIV) = JPIV
C
C      PRINT OUT THE TABLEAU MATRIX
C
      NDUM=NUMSEC+5
      DO 1400 I=1,NRBBQMAT
      TABLEA(I, NRBBQMAT)=QBMAT(I,1)
      TABLEA(I,NDUM) = YSUBK(I,1)
 1400 CONTINUE
C     CALL MATOUT(TABLEA, NRBBQMAT, NDUM, 24,25, 5)
C
C     WRITE(2, 60) JPIV, IPIV, IPIVDU
C
C      ROW TRANSFORMATIONS FOR BBQMAT AND QBMAT
C
C
      CALL MATRAN(BBQMAT, NRBBQMAT, NCBBQMAT, 24, 24, YSUBK, IPIVDU)
C     CALL MATOUT(BBQMAT, NRBBQMAT, NCBBQMAT, 24, 24, 6)
C
      CALL MATRAN(QBMAT, NRBBQMAT, 1, 24, 1, YSUBK, IPIVDU)
C     CALL MATOUT(QBMAT, NRBBQMAT, 1, 24, 1, 8)
C
C     CALL SOLUTION(NUMSECAD, QBMAT, NRBBQMAT, 1, 24, 1, LABR, 23)
C
C      IF OPTIMUM POINT HAS BEEN REACHED GO TO 1500;
C      OTHERWISE CONTINUE WITH THE ITERATIONS
C
      IF (QBMAT(1, 1) .GE.     D2  ) GO TO 1500
      GO TO 9999
C
C
 1500 CONTINUE
C
C
C     WRITE(2, 30) ITERAT
C     CALL MATOUT(TABLEA, NRBBQMAT, NDUM, 24,25, 5, 0)
      CALL SOLUTION(NUMSECAD, QBMAT, NRBBQMAT, 1, 24, 1, LABR, 23)
C
      DO 1600 I = 1, NRQMAT
      NDUM = LABR(I)
      IF (NDUM .GT. NUMSECAD) GO TO 1600
C
      QQBMAT(NDUM, NTHETA) = QBMAT(I+1, 1)
C
C      CALCULATION OF THE EXPECTED RETURN AND VARIANCE OF RETURN
C      OF THE EFFICIENT PORTFOLIO, GIVEN THETA
C
      ROR(NTHETA) = ROR(NTHETA) + EMAT(NDUM) * QBMAT(I+1, 1)
      VARROR(NTHETA) = VARROR(NTHETA) -
```

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PORTFOLIO ANALYSIS FOR SELECTED HONG KONG SECURITIES -- SOURCE PROGRAM 2

```
     *                      DMAT(NDUM, NDUM) * (QBMAT(I+1, 1) ** 2)
 1600 CONTINUE
      SDROR(NTHETA) = SQRT(VARROR(NTHETA))
C
C
      GO TO 8888
C
C
C        PRINTING OF FINAL SOLUTIONS AND GRAPH OF EFFICIENT FRONTIERS
C
C
 2000 CONTINUE
      NTHETA = NTHETA - 1
C
      WRITE(4, 9)
      CALL CRPORT
C
      WRITE(6, 10) NTHETA
      DO 2100 I = 1, NTHETA
 2100 WRITE(6, 70) ROR(I), VARROR(I), SDROR(I), THETA(I),
     *  (QQBMAT(J, I), J = 1, NUMSECAD)
C
      CALL RPLACE(ROR, VARROR, XDUMMY, YDUMMY, NTHETA)
      CALL GPLOT(XDUMMY, YDUMMY, NTHETA, XMAX, XMIN, YMAX, YMIN, 1, 1)
      WRITE(2, 80)
C
      XMAX = 0.25
      XMIN = 0.00
      YMAX = 0.20
      YMIN = 0.00
      CALL RPLACE(ROR, VARROR, XDUMMY, YDUMMY, NTHETA)
      CALL GPLOT(XDUMMY, YDUMMY, NTHETA, XMAX, XMIN, YMAX, YMIN, 0, 2)
      WRITE(2, 80)
C
      CALL RPLACE(ROR,  SDROR, XDUMMY, YDUMMY, NTHETA)
      CALL GPLOT(XDUMMY, YDUMMY, NTHETA, XMAX, XMIN, YMAX, YMIN, 1, 3)
      WRITE(2, 90)
C
      XMAX = 0.25
      XMIN = 0.00
      YMAX = 0.50
      YMIN = 0.00
      CALL RPLACE(ROR,  SDROR, XDUMMY, YDUMMY, NTHETA)
      CALL GPLOT(XDUMMY, YDUMMY, NTHETA, XMAX, XMIN, YMAX, YMIN, 0, 4)
      WRITE(2, 90)
C
C
    9 FORMAT(1H1)
   10 FORMAT(8I10)
   19 FORMAT(16A4, 1X, 2A4, A2, I2, 1X, I2)
   20 FORMAT(4D20.8)
   30 FORMAT(1H0/// 12H THIS IS THE , I3, 13H TH ITERATION , 10X,
```

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```
     *30H********************************,////)
   40 FORMAT(1H0,12F10.4)
   50 FORMAT(1H0, 120(1H*)/
     11H0, 10X, 'NTHETA = ', I2, 10X, 'THETA = ', F20.10/
     21H , 120(1H*)////)
   60 FORMAT(///1H , 9HJPIV    = , I4/
     *           1H , 9HIPIV    = , I4/
     *           1H , 9HIPIVDU = , I4/)
   70 FORMAT(8F10.8)
   80 FORMAT(1H0, 20X, 'PLOT OF EFFICIENT FRONTIER WITH VARIANCE AGAINST
     1 EXPECTED RETURN'/)
   90 FORMAT(1H0, 20X, 'PLOT OF EFFICIENT FRONTIER WITH STANDARD DEVIATI
     *ON AGAINST EXPECTED RETURN' /)
C
      STOP
      END
```

```
                    -----------------------------
                    I                           I
                    I     S U B R O U T I N E   I
                    I                           I
                    -----------------------------
```

```
      SUBROUTINE MATOUT (A,NR,NC,IDEM,JDEM,N, KEY)
C
C
C        NR = NUMBER OF ROWS OF 'A'
C        NC = NUMBER OF COLUMNS OF 'A'
C        IF N = 0, NO TITLE WILL BE PRINTED
C        IF N = M, THE TITLE CORRESPONDING TO M WILL BE PRINTED
C        IF KEY = 0, 15 COLUMNS PER PAGE OF 'A' WILL BE PRINTED
C        IF KEY = 1, 10 COLUMNS PER PAGE OF 'A' WILL BE PRINTED
C
      DIMENSION A(IDEM,JDEM)
      DIMENSION ITITLE(10)
      DOUBLE PRECISION A
      DATA ITITLE(1)/3H C /
      DATA ITITLE(2)/4HDMAT/
      DATA ITITLE(3)/4HEMAT/
      DATA ITITLE(4)/4HOMAT/
      DATA ITITLE(5)/6HTABLEA/
      DATA ITITLE(6)/6HBROMAT/
      DATA ITITLE(7)/5HYSUBK/
      DATA ITITLE(8)/5HORMAT/
C
      IDENOM = 15
      IF (KEY .EQ. 1) IDENOM = 10
      NP = NC / IDENOM
```

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```
      NTEST = NP * IDENOM
      IF (NC .NE. NTEST) NP = NP + 1
C
      DO 1000 IP =1, NP
      JE = IP * IDENOM
      JB = JE - IDENOM + 1
      IF (JE .GT. NC) JE = NC
      WRITE(2, 600)
      IF (N .EQ. 0) GO TO 99
      WRITE(2, 500) ITITLE(N), NR, NC
   99 WRITE(2, 300)
      IF (KEY .EQ. 1) GO TO 298
      WRITE(2, 400) (J, J = JB, JE)
      GO TO 299
  298 WRITE(2, 401) (J, J = JB, JE)
  299 WRITE(2, 300)
      IF (KEY .EQ. 1) GO TO 199
C
      DO 100 I = 1, NR
  100 WRITE(2, 601) (A(I, J), J = JB, JE)
C
      GO TO 1000
C
  199 DO 200 I = 1, NR
  200 WRITE(2, 602) (A(I, J), J = JB, JE)
C
 1000 CONTINUE
C
  300 FORMAT(1H , 120(1H-))
  400 FORMAT(1H , 15(3X, I2, 3X)  )
  401 FORMAT(1H , 10(5X, I2, 5X))
  500 FORMAT(1H0, 9HMATRIX ' ,A6, 3H ' , 10X,
     *              12HDIMENSION : ,I2,3H X , I2,///)
  600 FORMAT (1H0////)
  601 FORMAT(1H , 15F8.3)
  602 FORMAT(1H , 10F12.8)
C
      RETURN
      END
```

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PORTFOLIO ANALYSIS FOR SELECTED HONG KONG SECURITIES -- SOURCE PROGRAM 2

```
                    --------------------------------
                    I                              I
                    I     S U B R O U T I N E      I
                    I                              I
                    --------------------------------

      SUBROUTINE SOLUTION(N, A, NRA, NCA, NRDA, NCDA, L, NL)
C
      DIMENSION A(NRDA, NCDA), L(NL)
      DIMENSION THETA(50)
      DOUBLE PRECISION A, THETA
      COMMON/ATHET/THETA, NTHETA
C
  300 FORMAT(1H1)
C     WRITE(2, 70) NTHETA, THETA
C     WRITE(2, 200)
  200 FORMAT(70H THE FEASIBLE SOLUTION TO THE PROBLEM  (*)  IS GIVEN AS
     * FOLLOWS :                                  ,///)
      NDUM = NRA - 1
      DO 100 I=1, NDUM
      IF (L(I) .LE. N) GO TO  110
      IF (L(I) .LE. N+2)  GO TO 120
      IF (L(I) .LE. N+4) GO TO 130
      IF (L(I) .GT. N+4 .AND. L(I).LE. 2*N+4) GO TO 140
      IF (L(I) .LE. 3*N+4) GO TO 150
      CALL ERROR(2)
  110 WRITE(2,10) L(I), A(I+1,1)
      GO TO 100
  120 WRITE(2, 20) L(I), A(I+1, 1)
      GO TO 100
  130 WRITE(2, 30)  L(I), A(I+1, 1)
      GO TO 100
  140 WRITE(2,40) L(I), A(I+1,1)
      GO TO 100
  150 WRITE(2, 50) L(I), A(I+1,1)
  100 CONTINUE
C
      WRITE(2, 60) A(1,1)
C
   10 FORMAT(1H0, 4H X( , I2,7H )    = , F10.8)
   20 FORMAT(1H0, 4H S( ,I2, 7H )    = , F10.8)
   30 FORMAT(1H0, 4H T( , I2, 7H )    = , F10.8)
   40 FORMAT(1H0,4H V( ,I2, 7H )    = , F10.8)
   50 FORMAT(1H0, 4H U( , I2, 7H )    = , F10.8)
   60 FORMAT(//1H0, 30H THE OBJECTIVE FUNCTION   =        , F16.10)
   70 FORMAT(1H0, ' NTHETA = ' ,I4/
     *         1H0, ' THETA  = ' ,D20.10///)
C
      RETURN
      END
```

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      SUBROUTINE CRPORT
      DIMENSION THETA(50)
      DIMENSION QQBMAT(21, 50)
      DIMENSION ROR(50), VARROR(50), SDROR(50)
      DOUBLE PRECISION QQBMAT, THETA
      COMMON/*THET/THETA, NTHETA
      COMMON  /CORNER/ ROR, VARROR, SDROR, QQBMAT
C
      IDENOM = 10
      NR = 20
      NC = NTHETA
      NP = NC / IDENOM
      NTEST = NP * IDENOM
      IF (NC .NE. NTEST) NP = NP + 1
C
      DO 1000 IP = 1, NP
      JE = IP * IDENOM
      JB = JE - IDENOM + 1
      IF (JE .GT. NC) JE = NC
      WRITE(4, 10)
   10 FORMAT(1H0, 120(1H-))
      WRITE(4, 20) (J, J = JB, JE)
   20 FORMAT(1H0, 'NUMBER :  ', 10(4X, I2, 5X))
      WRITE(4, 10)
      WRITE(4, 30) (THETA(J), J = JB, JE)
   30 FORMAT(1H0, 'THETA  :  ', 10(1X, F10.8))
      WRITE(4, 10)
      DO 100 I = 1, NR
  100 WRITE(4, 40) I, (QQBMAT(I, J), J = JB, JE)
   40 FORMAT(1H , 'X(',I2, ')  :  ', 10(1X, F10.8))
      WRITE(4, 10)
      WRITE(4, 50) (ROR(J), J = JB, JE)
   50 FORMAT(1H0, 'ROR    :  ', 10(1X, F10.8))
      WRITE(4, 60) (VARROR(J), J = JB, JE)
   60 FORMAT(1H0, 'VARROR :  ', 10(1X, F10.8))
      WRITE(4, 70) (SDROR(J), J = JB, JE)
   70 FORMAT(1H0, 'SDROR  :  ', 10(1X, F10.8))
      WRITE(4, 10)
      WRITE(4, 80)
   80 FORMAT(1H1)
 1000 CONTINUE
C
      RETURN
      END
```

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      SUBROUTINE RPLACE(X, Y, A, B, N)
C
      DIMENSION A(50), B(50)
      DIMENSION X(50), Y(50)
C
      DO 100 I = 1, N
      A(I) = X(I)
      B(I) = Y(I)
  100 CONTINUE
C
      RETURN
      END


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      SUBROUTINE  MATRAN(A, NR, NC, IDEM, JDEM,B, K)
C
C
C       THIS SUBROUTINE SERVES TO MAKE ROW TRANSFORMATIONS ON THE
C       GIVEN MATRIX 'A' , USING THE 'RING AROUND THE ROSY' METHOD
C
C
      DIMENSION A(IDEM,JDEM), B(IDEM,1)
      DOUBLE PRECISION A, B
C
      DO 100 J=1, NC
  100 A(K,J) = A(K,J)/B(K,1)
C
      DO 200 I=1, NR
      IF (I.EQ.K) GO TO 200
      DO 200 J=1, NC
      A(I,J) = A(I,J) - B(I,1) * A(K,J)
  200 CONTINUE
C
      RETURN
      END
```

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```

```
      SUBROUTINE ERROR(K)
C
      DIMENSION ERRAR(10)
      DATA ERRAR(1)/6HERROR1/
      DATA ERRAR(2)/6HERROR2/
      DATA ERRAR(3)/6HERROR3/
C
      WRITE(2, 10) ERRAR(K)
   10 FORMAT(1H1, A6)
C
      STOP
      END
      FINISH
```

END OF PROGRAM

APPENDIX G

SOURCE PROGRAM III FOR CONSTRUCTING THE EFFICIENT PORTFOLIO

PORTFOLIO ANALYSIS FOR SELECTED HONG KONG SECURITIES -- SOURCE PROGRAM 3

```
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
C                                                                      C
C       THIS PROGRAM READS IN THE RISK PREFERENCE  OF THE INVESTOR     C
C       FINDS HIS EFFICIENT PORTFOLIO AND PLOTS OUT THE EFFICIENT      C
C       FRONTIER                                                       C
C       PROGRAMMED BY  ALEX LAM        JANUARY 1974                    C
C                                                                      C
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC


                    ------------------------------
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      MASTER ALEX
      DIMENSION RORSEC(21), VARSEC(21),SDSEC(21)
      DIMENSION ROR(50), VARROR(50), SDROR(50)
      DIMENSION THETA(50), OBBMAT(21, 50)
      DIMENSION XDUMMY(50), YDUMMY(50)
      DIMENSION NAMSEC(20, 16), NAMABB(20, 3), INDUST(20)
      DIMENSION ALPHA(20), BETA(20), IARANK(20), IBRANK(20)
      COMMON /ALL/ RORSEC, SDSEC,          NAMABB, INDUST, BETA, ALPHA,
     *  IBRANK, IARANK, NUMSEC, RORPOT, SDPORT
C
      READ(3, 10) NUMSEC
C
      DO 100 I = 1, NUMSEC
      READ(3, 30) (NAMSEC(I, J), J=1,16), (NAMABB(I, J), J=1,3),
     * INDUST(I), II
      IF (I. NE. II) CALL ERROR(1)
      READ(3, 35) RORSEC(I), VARSEC(I), BETA(I), ALPHA(I)
   35 FORMAT(4F20.8)
  100 CONTINUE
C
   30 FORMAT(16A4, 1X, 2A4, A2, I2, 1X, I2)
      READ(3, 35) VARIND
C
      DO 110 I = 1, NUMSEC
      VARSEC(I) = VARSEC(I) + VARIND * (BETA(I) ** 2)
      SDSEC(I) = SQRT(VARSEC(I))
  110 CONTINUE
   10 FORMAT(8I10)
C
      CALL RANK(ALPHA, IARANK, NUMSEC)
      CALL RANK(BETA, IBRANK, NUMSEC)
C
      NUMSECAD = NUMSEC + 1
C
```

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PORTFOLIO ANALYSIS FOR SELECTED HONG KONG SECURITIES -- SOURCE PROGRAM 3

```
      READ(1, 10) NTHETA
C
      DO 150 I = 1, NTHETA
  150 READ(1, 20) ROR(I), VARROR(I), SDROR(I), THETA(I),
     *  (QQRMAT(J, I), J = 1, NUMSECAD)
   20 FORMAT(8F10.8)
  111 READ(5, 20, END=444) RTHETA
      IF (RTHETA .EQ. -1.) GO TO 310
C
      DO 200 I = 1, NTHETA
      IF (THETA(I) .GT. RTHETA) GO TO 200
      ITHETA = I
      DUMMY1 = THETA(I)
  200 CONTINUE
C
      DUMMY2 = THETA(ITHETA + 1)
      DIFF   = DUMMY2 - DUMMY1
      DIFF1  = RTHETA - DUMMY1
      DIFF2  = DUMMY2 - RTHETA
      R1     = DIFF1 / DIFF
      R2     = DIFF2 / DIFF
C
      RORPOT = ROR(ITHETA) * R2  +  ROR(ITHETA+1) * R1
      SDPORT = SDROR(ITHETA) * R2  +  SDROR(ITHETA + 1) * R1
C
      DO 300 I = 1, NUMSECAD
  300 XDUMMY(I) = QQRMAT(I, ITHETA) * R2 + QQRMAT(I, ITHETA+1) * R1
      CALL PORTFOLIO(XDUMMY, RTHETA)
C
      GO TO 111
C
  310 READ(5, 40, END=444) ISWT1, XMAX, XMIN, YMAX, YMIN
      IF (ISWT1 .EQ. 2) GO TO 320
   40 FORMAT(I1, F9.4, 7F10.4)
      CALL RPLACE(ROR, SDROR , XDUMMY, YDUMMY, NTHETA)
      WRITE(2, 50)
      CALL GPLOT(XDUMMY, YDUMMY, NTHETA, XMAX, XMIN,YMAX,YMIN,ISWT1,0)
   50 FORMAT(1H1     , 20X, 'PLOT OF EFFICIENT FRONTIER WITH STANDARD DEV
     *IATION AGAINST EXPECTED RETURN'//)
      GO TO 310
  320 READ(5, 40, END=444) ISWT1, XMAX, XMIN, YMAX, YMIN
      CALL RPLACE(ROR, VARROR, XDUMMY, YDUMMY, NTHETA)
      WRITE(2, 60)
      CALL GPLOT(XDUMMY, YDUMMY, NTHETA, XMAX, XMIN,YMAX,YMIN,ISWT1,0)
   60 FORMAT(1H1, 20X, 'PLOT OF EFFICIENT FRONTIER WITH VARIANCE AGAINST
     * EXPECTED RETURN'//)
      GO TO 320
  444 STOP
      END
```

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      SUBROUTINE RANK(A, IRANK, N)
      DIMENSION A(20),X(20), IRANK(20)
C
      DO 100 I = 1, N
  100 X(I) = A(I)
      JMAX = 1
C
      DO 200 I = 1, N
      DO 200 J = I, N
      IF (X(J) .LE. X(I)) GO TO 200
      TEMP = X(J)
      X(J) = X(I)
      X(I) = TEMP
  200 CONTINUE
C
      DO 300 I = 1, N
      DO 310  J = 1, N
      IF (A(J) .NE. X(I)) GO TO 310
      IRANK(J) = I
      GO TO 300
  310 CONTINUE
  300 CONTINUE
C
      RETURN
      END

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      SUBROUTINE PORTFOLIO(XDUMMY, RTHETA)
C
      DIMENSION RORSEC(21), SDSEC(21)
      DIMENSION XDUMMY(50)
      DIMENSION ROR(50), VARROR(50), SDROR(50)
      DIMENSION NAMABB(20, 3), INDUST(20)
      DIMENSION BETA(20), ALPHA(20), IBRANK(20), IARANK(20)
```

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PORTFOLIO ANALYSIS FOR SELECTED HONG KONG SECURITIES -- SOURCE PROGRAM 3

```
      COMMON /ALL/ RORSEC, SDSEC,        NAMABR, INDUST, BETA, ALPHA,
     *  IBRANK, IARANK, NUMSEC, RORPOT, SDPORT
C
      WRITE(2, 10) RTHETA
   10 FORMAT(1H1/ 1H ,22X, 'T H E      P O R T F O L I O'//
     *              1H ,22X,'RISK PREFERENCE  =  ', F7.4//
     *              1H , 72(1H-)/1H0,
     *' S E C U R I T Y      RATE OF   STANDARD    A L P H A      B E T A'/
     * 1H , 'NO    NAME     IND  RETURN   ERROR    COEFF  RANK  COEFF
     *RANK FRACTION'/ 1H0, 72(1H-) )
C
      DO 100 I = 1, NUMSEC
  100 WRITE(2, 20) I, (NAMABR(I, J), J=1,3), INDUST(I), RORSEC(I),
     * SDSEC(I)
     * ,ALPHA(I), IARANK(I), BETA(I), IBRANK(I), XDUMMY(I)
   20 FORMAT(1H0,I2,2X, 2A4, A2, 2X, I2, 2X, 2(F7.4, 2X),
     * 2(F7.4, 2X, I2, 2X), F7.4)
      WRITE(2, 30)
   30 FORMAT(1H0, 72(1H-))
      WRITE(2, 40) RORPOT, SDPORT, XDUMMY(NUMSEC+1)
   40 FORMAT(1H0, 10X, 'RETURN', 21X, ':', 13X, F7.4/
     *            1H0, 10X, 'STANDARD ERROR', 13X, ':', 13X, F7.4/
     * 1H0, 10X, 'BETA COEFFICIENT', 11X, ':', 13X, F7.4/)
C
      RETURN
      END
```

```
                         ------------------------------------
                         I                                  I
                         I      S U B R O U T I N E         I
                         I                                  I
                         ------------------------------------
```

```
      SUBROUTINE RPLACE(X, Y, A, B, N)
C
C       THIS SUBROUTINE REPLACES THE X AND Y ARRAYS BY A AND B ARRAYS
C
      DIMENSION A(50), B(50)
      DIMENSION X(50), Y(50)
C
      DO 100 I = 1, N
      A(I) = X(I)
      B(I) = Y(I)
  100 CONTINUE
C
      RETURN
      END
```

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```
          ------------------------------
          I                            I
          I     S U B R O U T I N E    I
          I                            I
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```

```
      SUBROUTINE ERROR(K)
C
C        THIS IS AN ERROR SUBROUTINE WHICH WILL STOP THE PROGRAM
C        WHENEVER ERROR IS DETECTED
C
C
      DIMENSION ERRAR(10)
      DATA ERRAR(1)/6HERROR1/
      DATA ERRAR(2)/6HERROR2/
      DATA ERRAR(3)/6HERROR3/
C
      WRITE(2, 10) ERRAR(K)
   10 FORMAT(1H1, A6)
C
      STOP
      END
      FINISH
```

END OF PROGRAM

APPENDIX H

DATA COLLECTED FOR THE TWENTY STOCKS

THE HONGKONG AND SHANGHAI BANKING CORPORATION 1

HK BANK BANKING

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	131.00	1.00	0.00	4.56	0.00	0.0041
2	68	II	140.00	1.00	0.00	0.00	0.00	0.0687
3	68	III	153.00	1.00	0.00	3.50	0.00	0.1179
4	68	IV	199.00	1.00	0.00	0.00	0.00	0.3007
5	69	I	173.00	1.00	0.10	5.46	0.00	-0.0163
6	69	II	191.00	1.00	0.00	0.00	0.00	0.1040
7	69	III	204.00	1.00	0.00	4.00	0.00	0.0890
8	69	IV	246.00	1.00	0.00	0.00	0.00	0.2059
9	70	I	152.00	1.00	1.00	3.50	0.00	0.2500
10	70	II	155.00	1.00	0.00	0.00	0.00	0.0197
11	70	III	163.00	1.00	0.00	1.68	0.00	0.0625
12	70	IV	185.00	1.00	0.00	0.00	0.00	0.1350
13	71	I	172.00	1.00	0.10	3.50	0.00	0.0416
14	71	II	266.00	1.00	0.00	0.00	0.00	0.4302
15	71	III	260.00	1.00	0.00	1.75	0.00	0.0640
16	71	IV	270.00	1.00	0.00	0.00	0.00	0.0385
17	72	I	242.00	1.00	0.10	3.50	0.00	-0.0011
18	72	II	282.00	1.00	0.00	0.00	0.00	0.1653
19	72	III	258.00	1.00	0.00	1.75	0.00	-0.0789
20	72	IV	388.00	1.00	0.00	0.00	0.00	0.5039
21	73	I	236.00	1.00	0.20	3.75	0.00	-0.2604
22	73	II	31.00	10.00	0.00	0.00	0.00	0.3136
23	73	III	27.10	1.00	0.00	0.20	0.00	-0.1194
24	73	IV	28.80	1.00	0.00	0.00	0.00	0.0627

AVERAGE RETURN	:	0.1042
VARIANCE OF RETURN	:	0.0287
STANDARD DEVIATION	:	0.1693
ALPHA COEFFICIENT	:	0.0792
BETA COEFFICIENT	:	0.2326

THE HONGKONG AND YAUMATI FERRY COMPANY LIMITED

HK & YAU TRANSPORT

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	36.00	1.00	0.00	3.00	0.00	0.0263
2	68	II	35.75	1.00	0.00	0.00	0.00	-0.0069
3	68	III	48.00	1.00	0.00	1.00	0.00	0.3706
4	68	IV	55.50	1.00	0.00	0.00	0.00	0.1563
5	69	I	49.75	1.00	0.00	3.00	0.00	-0.0495
6	69	II	45.00	1.00	0.00	0.00	0.00	-0.0955
7	69	III	60.00	1.00	0.00	1.00	0.00	0.3556
8	69	IV	61.50	1.00	0.00	0.00	0.00	0.0250
9	70	I	66.50	1.00	0.00	3.50	0.00	0.1382
10	70	II	60.00	1.00	0.00	0.00	0.00	-0.0977
11	70	III	65.50	1.00	0.00	1.00	0.00	0.1083
12	70	IV	69.50	1.00	0.00	0.00	0.00	0.0611
13	71	I	66.50	1.00	0.00	3.50	0.00	0.0072
14	71	II	75.00	1.00	0.00	0.00	0.00	0.1278
15	71	III	81.00	1.00	0.00	1.00	0.00	0.0933
16	71	IV	66.50	1.00	0.00	0.00	0.00	-0.1790
17	72	I	70.50	1.00	0.00	4.00	0.00	0.1203
18	72	II	74.00	1.00	0.00	0.00	0.00	0.0496
19	72	III	86.50	1.00	0.00	1.00	0.00	0.1824
20	72	IV	135.00	1.00	0.00	0.00	0.00	0.5607
21	73	I	69.00	1.00	1.00	3.50	0.00	0.0481
22	73	II	31.00	1.00	0.00	0.00	6.00	-0.4638
23	73	III	23.00	1.00	0.00	0.50	0.00	-0.2419
24	73	IV	18.50	1.00	0.00	0.00	0.00	-0.1957

AVERAGE RETURN	:	0.0459
VARIANCE OF RETURN	:	0.0448
STANDARD DEVIATION	:	0.2117
ALPHA COEFFICIENT	:	-0.0314
BETA COEFFICIENT	:	0.7184

THE KOWLOON MOTOR BUS COMPANY LIMITED 3

K.M. BUS TRANSPORT

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	15.50	1.00	0.00	0.05	0.00	-0.1595
2	68	II	16.50	1.00	0.00	0.00	0.00	0.0645
3	68	III	22.80	1.00	0.00	0.05	0.00	0.4394
4	68	IV	28.70	1.00	0.00	0.00	0.00	0.2588
5	69	I	31.75	1.00	0.00	0.05	0.00	0.1030
6	69	II	31.75	1.00	0.00	0.00	0.00	0.0000
7	69	III	34.25	1.00	0.00	1.20	0.00	0.1165
8	69	IV	31.00	1.00	0.00	0.00	0.00	-0.0949
9	70	I	34.50	1.00	0.00	0.05	0.00	0.1145
10	70	II	33.00	1.00	0.00	0.00	0.00	-0.0435
11	70	III	41.00	1.00	0.00	1.70	0.00	0.2939
12	70	IV	40.25	1.00	0.00	0.00	0.00	-0.0183
13	71	I	39.50	1.00	0.00	0.05	0.00	-0.0174
14	71	II	47.75	1.00	0.00	0.00	0.00	0.2089
15	71	III	53.50	1.00	0.00	1.70	0.00	0.1560
16	71	IV	58.00	1.00	0.00	0.00	0.00	0.0841
17	72	I	62.50	1.00	0.00	0.10	0.00	0.0793
18	72	II	76.00	1.00	0.00	0.00	0.00	0.2160
19	72	III	139.00	1.00	0.50	1.70	0.00	1.7658
20	72	IV	234.00	1.00	0.00	0.00	0.00	0.6835
21	73	I	38.00	10.00	0.00	0.90	0.00	0.6278
22	73	II	18.00	1.00	0.00	0.00	0.00	-0.5263
23	73	III	8.50	1.00	0.60	0.15	0.00	-0.2361
24	73	IV	6.80	1.00	0.00	0.09	0.00	-0.1894

AVERAGE RETURN : 0.1638

VARIANCE OF RETURN : 0.1851

STANDARD DEVIATION : 0.4303

ALPHA COEFFICIENT : 0.0580

BETA COEFFICIENT : 0.9844

JARDINE SECURITIES LIMITED

JARD SEC INVESTMENT

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	10.30	1.00	0.00	0.40	0.00	-0.0273
2	68	II	12.60	1.00	0.00	0.00	0.00	0.2233
3	68	III	15.00	1.00	0.10	0.75	0.00	0.3690
4	68	IV	17.00	1.00	0.00	0.00	0.00	0.1333
5	69	I	17.00	1.00	0.00	0.45	0.00	0.0265
6	69	II	21.80	1.00	0.00	0.00	0.00	0.2824
7	69	III	12.90	2.00	0.10	0.75	0.00	0.3362
8	69	IV	13.50	1.00	0.00	0.00	0.00	0.0465
9	70	I	14.10	1.00	0.00	0.25	0.00	0.0630
10	70	II	12.90	1.00	0.13	0.00	0.23	0.0452
11	70	III	14.60	1.00	0.00	0.45	0.00	0.1667
12	70	IV	14.30	1.00	0.00	0.00	0.00	-0.0205
13	71	I	13.50	1.00	0.00	0.25	0.00	-0.0385
14	71	II	19.00	1.00	0.00	0.00	0.00	0.4074
15	71	III	18.50	1.00	0.10	0.45	1.20	0.1579
16	71	IV	18.90	1.00	0.00	0.00	0.00	0.0216
17	72	I	20.90	1.00	0.00	0.25	0.00	0.1190
18	72	II	30.00	1.00	0.00	0.00	0.00	0.4354
19	72	III	19.40	1.00	1.00	0.45	0.00	0.3083
20	72	IV	34.50	1.00	0.00	0.00	0.00	0.7784
21	73	I	26.50	1.00	0.00	0.15	0.00	-0.2275
22	73	II	12.70	1.00	1.00	0.00	1.83	0.0275
23	73	III	10.60	1.00	0.00	0.13	0.00	-0.1555
24	73	IV	7.40	1.00	0.00	0.00	0.00	-0.3019

AVERAGE RETURN : 0.1324

VARIANCE OF RETURN : 0.0556

STANDARD DEVIATION : 0.2358

ALPHA COEFFICIENT : 0.0662

BETA COEFFICIENT : 0.6153

EASTERN ASIA NAVIGATION COMPANY LIMITED 5

E.A. NAV. SHIPPING

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	2.35	1.00	0.00	0.05	0.00	0.0909
2	68	II	2.00	1.00	0.00	0.00	0.00	-0.1489
3	68	III	2.25	1.00	0.00	0.03	0.00	0.1400
4	68	IV	1.80	1.00	0.00	0.00	0.00	-0.2000
5	69	I	2.35	1.00	0.00	0.07	0.00	0.3444
6	69	II	2.35	1.00	0.00	0.00	0.00	0.0000
7	69	III	2.65	1.00	0.00	0.05	0.33	0.2872
8	69	IV	3.00	1.00	0.00	0.00	0.00	0.1321
9	70	I	3.70	1.00	0.00	0.09	0.00	0.2633
10	70	II	3.40	1.00	0.00	0.00	0.00	-0.0811
11	70	III	3.60	1.00	0.00	0.06	0.00	0.0765
12	70	IV	7.25	1.00	0.00	0.00	0.00	1.0139
13	71	I	6.60	1.00	0.00	0.13	0.00	-0.0717
14	71	II	9.90	1.00	0.00	0.00	0.00	0.5000
15	71	III	8.80	1.00	0.00	0.09	0.90	-0.0111
16	71	IV	9.00	1.00	0.00	0.00	0.00	0.0227
17	72	I	8.95	1.00	0.00	0.20	0.00	0.0167
18	72	II	17.50	1.00	0.00	0.00	0.00	0.9553
19	72	III	19.40	1.00	0.20	0.17	1.48	0.4246
20	72	IV	33.50	1.00	0.00	0.00	0.00	0.7268
21	73	I	23.60	1.00	1.00	0.30	0.00	0.4179
22	73	II	13.60	1.00	0.00	0.00	0.00	-0.4237
23	73	III	9.50	1.00	0.00	0.10	0.00	-0.2941
24	73	IV	7.50	1.00	0.00	0.00	0.00	-0.2105

AVERAGE RETURN	:	0.1655
VARIANCE OF RETURN	:	0.1358
STANDARD DEVIATION	:	0.3685
ALPHA COEFFICIENT	:	0.0669
BETA COEFFICIENT	:	0.9169

HONGKONG AND WHAMPOA DOCK COMPANY LIMITED

HK DOCK DOCKYARD

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	26.20	1.00	0.00	0.00	0.00	-0.0807
2	68	II	28.10	1.00	0.00	0.15	0.00	0.0782
3	68	III	35.50	1.00	0.00	0.00	0.00	0.2633
4	68	IV	43.25	1.00	0.00	0.10	0.00	0.2211
5	69	I	44.50	1.00	0.00	0.00	0.00	0.0289
6	69	II	45.50	1.00	0.00	0.20	0.00	0.0270
7	69	III	66.00	1.00	0.00	0.00	0.00	0.4505
8	69	IV	72.00	1.00	0.00	0.20	0.00	0.0939
9	70	I	85.50	1.00	0.00	0.00	0.00	0.1875
10	70	II	9.40	10.00	0.00	0.25	0.00	0.1023
11	70	III	11.20	1.00	0.00	0.00	0.00	0.1915
12	70	IV	11.50	1.00	0.00	0.20	0.00	0.0446
13	71	I	11.10	1.00	0.05	0.00	0.00	0.0135
14	71	II	15.60	1.00	0.00	0.25	0.00	0.4279
15	71	III	19.50	1.00	0.00	0.00	0.00	0.2500
16	71	IV	19.70	1.00	0.00	0.20	0.00	0.0205
17	72	I	19.90	1.00	0.05	0.00	0.00	0.0607
18	72	II	25.00	1.00	0.00	0.30	0.00	0.2714
19	72	III	27.70	1.00	0.00	0.00	0.00	0.1080
20	72	IV	47.00	1.00	0.00	0.20	0.00	0.7040
21	73	I	72.00	1.00	0.00	0.00	0.00	0.5319
22	73	II	28.10	1.00	0.05	0.40	0.00	-0.5847
23	73	III	23.20	1.00	0.00	0.00	0.00	-0.1744
24	73	IV	19.50	1.00	0.00	1.80	0.00	-0.0819

AVERAGE RETURN : 0.1315

VARIANCE OF RETURN : 0.0655

STANDARD DEVIATION : 0.2559

ALPHA COEFFICIENT : 0.0221

BETA COEFFICIENT : 1.0167

TAIKOO SWIRE LIMITED 7

SWIRE DOCKYARD

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	16.90	1.00	0.00	0.00	0.00	-0.0174
2	68	II	15.20	1.00	0.00	1.50	0.00	-0.0118
3	68	III	21.80	1.00	0.00	0.00	0.00	0.4342
4	68	IV	28.20	1.00	0.00	1.00	0.00	0.3394
5	69	I	31.50	1.00	0.00	0.00	0.00	0.1170
6	69	II	30.50	1.00	0.00	1.60	0.00	0.0190
7	69	III	37.50	1.00	0.00	0.00	0.00	0.2295
8	69	IV	47.00	1.00	0.00	1.20	0.00	0.2853
9	70	I	54.00	1.00	0.00	0.00	0.00	0.1489
10	70	II	58.50	1.00	0.00	2.00	0.00	0.1204
11	70	III	69.50	1.00	0.00	0.00	0.00	0.1880
12	70	IV	83.00	1.00	0.00	1.60	0.00	0.2173
13	71	I	79.00	1.00	0.00	0.00	0.00	-0.0482
14	71	II	120.00	1.00	0.00	2.50	0.00	0.5506
15	71	III	178.00	1.00	0.00	0.00	0.00	0.4833
16	71	IV	17.90	5.00	1.00	2.00	0.00	0.0169
17	72	I	17.30	1.00	0.00	0.00	0.00	-0.0335
18	72	II	22.40	1.00	0.00	0.35	0.00	0.3150
19	72	III	27.10	1.00	0.00	0.00	0.00	0.2098
20	72	IV	58.00	1.00	0.00	0.10	0.00	1.1439
21	73	I	91.00	1.00	0.00	0.00	0.00	0.5690
22	73	II	10.30	2.00	0.00	0.55	6.75	-0.6934
23	73	III	9.10	1.00	0.00	0.00	0.00	-0.1165
24	73	IV	7.10	1.00	0.00	0.33	0.00	-0.1841

AVERAGE RETURN : 0.1784

VARIANCE OF RETURN : 0.1153

STANDARD DEVIATION : 0.3395

ALPHA COEFFICIENT : 0.0341

BETA COEFFICIENT : 1.3426

THE HONGKONG AND KOWLOON WHARF AND GODOWN COMPANY LIMITED 8

HK & K WH WHARF AND GODOWN

PERIOD	QUARTER YEARLY	MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68 I	11.20	1.00	0.00	0.00	0.00	-0.1385
2	68 II	13.50	1.00	0.00	0.90	0.00	0.2857
3	68 III	17.10	1.00	0.00	0.00	0.00	0.2667
4	68 IV	20.20	1.00	0.00	0.30	0.00	0.1988
5	69 I	21.40	1.00	0.00	0.00	0.00	0.0594
6	69 II	25.60	1.00	0.00	0.90	0.00	0.2383
7	69 III	33.75	1.00	0.00	0.00	0.00	0.3184
8	69 IV	35.75	1.00	0.00	0.40	0.00	0.0711
9	70 I	46.00	1.00	0.00	0.00	0.00	0.2867
10	70 II	24.90	1.00	1.00	1.40	0.00	0.1130
11	70 III	30.00	1.00	0.00	0.00	0.00	0.2048
12	70 IV	31.75	1.00	0.00	0.30	0.00	0.0683
13	71 I	32.75	1.00	0.00	0.00	0.00	0.0315
14	71 II	55.00	1.00	0.00	1.10	2.90	0.8015
15	71 III	72.00	1.00	0.00	0.00	0.00	0.3091
16	71 IV	69.00	1.00	0.00	0.40	0.00	-0.0361
17	72 I	72.50	1.00	0.00	0.00	0.00	0.0507
18	72 II	88.00	1.00	0.00	1.40	0.00	0.2331
19	72 III	138.00	1.00	0.00	0.00	0.00	0.5682
20	72 IV	264.00	1.00	0.00	0.50	0.00	0.9167
21	73 I	430.00	1.00	0.00	0.00	0.00	0.6288
22	73 II	24.70	1.00	5.00	1.80	0.00	-0.6512
23	73 III	24.30	1.00	0.00	0.00	0.00	-0.0162
24	73 IV	18.20	1.00	0.00	0.10	0.00	-0.2469

AVERAGE RETURN : 0.1901

VARIANCE OF RETURN : 0.1084

STANDARD DEVIATION : 0.3293

ALPHA COEFFICIENT : 0.0538

BETA COEFFICIENT : 1.2672

THE HONGKONG LAND COMPANY LIMITED 9

HK LAND LAND

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	31.50	1.00	0.00	2.30	0.00	-0.0273
2	68	II	39.00	1.00	0.00	0.00	0.00	0.2381
3	68	III	46.50	1.00	0.00	1.20	0.00	0.2231
4	68	IV	58.50	1.00	0.00	0.00	0.00	0.2581
5	69	I	57.50	1.00	0.00	1.55	0.00	0.0094
6	69	II	61.50	1.00	0.00	0.00	0.00	0.0696
7	69	III	75.50	1.00	0.00	1.80	0.00	0.2569
8	69	IV	89.00	1.00	0.00	0.00	3.62	0.2268
9	70	I	87.00	1.00	0.00	2.95	0.00	0.0107
10	70	II	88.50	1.00	0.00	0.00	0.00	0.0172
11	70	III	98.50	1.00	0.00	1.80	0.00	0.1333
12	70	IV	110.00	1.00	0.00	0.00	0.00	0.1168
13	71	I	99.00	1.00	0.00	3.20	0.00	-0.0709
14	71	II	33.75	5.00	0.00	0.00	3.80	0.7429
15	71	III	40.25	1.00	0.00	0.35	0.00	0.2030
16	71	IV	38.50	1.00	0.00	0.00	0.00	-0.0435
17	72	I	37.75	1.00	0.10	0.70	0.00	0.0968
18	72	II	55.00	1.00	0.00	0.00	0.00	0.4570
19	72	III	74.00	1.00	0.00	0.45	0.00	0.3536
20	72	IV	137.00	1.00	0.00	0.00	0.00	0.8514
21	73	I	36.50	1.00	5.00	0.84	0.00	0.6047
22	73	II	12.30	1.00	0.00	0.00	0.00	-0.6630
23	73	III	10.50	1.00	0.00	0.90	0.00	-0.0732
24	73	IV	8.65	1.00	0.00	0.00	0.00	-0.1762

AVERAGE RETURN	:	0.1590
VARIANCE OF RETURN	:	0.0970
STANDARD DEVIATION	:	0.3115
ALPHA COEFFICIENT	:	0.0252
BETA COEFFICIENT	:	1.2439

HONGKONG REALTY AND TRUST COMPANY LIMITED 10

HK REALTY LAND

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	0.85	1.00	0.00	0.02	0.00	-0.0225
2	68	II	1.10	1.00	0.00	0.00	0.00	0.2941
3	68	III	1.35	1.00	0.00	0.04	0.00	0.2636
4	68	IV	1.64	1.00	0.00	0.00	0.00	0.2148
5	69	I	1.66	1.00	0.00	0.02	0.00	0.0244
6	69	II	1.66	1.00	0.00	0.00	0.00	0.0000
7	69	III	2.33	1.00	0.00	0.05	0.00	0.4307
8	69	IV	2.25	1.00	0.00	0.00	0.00	-0.0323
9	70	I	2.33	1.00	0.10	0.05	0.41	0.3420
10	70	II	2.75	1.00	0.00	0.00	0.00	0.1828
11	70	III	2.85	1.00	0.00	0.06	0.00	0.0582
12	70	IV	3.00	1.00	0.00	0.00	0.00	0.0526
13	71	I	2.65	1.00	0.00	0.06	0.00	-0.0967
14	71	II	3.45	1.00	0.00	0.00	0.00	0.3019
15	71	III	4.10	1.00	0.00	0.06	0.35	0.3072
16	71	IV	3.80	1.00	0.00	0.00	0.00	-0.0732
17	72	I	3.75	1.00	0.00	0.06	0.00	0.0026
18	72	II	4.37	1.00	0.00	0.00	0.00	0.1667
19	72	III	4.60	1.00	0.00	0.07	0.00	0.0674
20	72	IV	8.00	1.00	0.00	0.00	0.00	0.7391
21	73	I	9.20	1.00	0.00	0.07	0.00	0.1587
22	73	II	4.30	1.00	0.00	0.00	0.00	-0.5326
23	73	III	3.33	1.00	0.00	0.07	0.00	-0.2105
24	73	IV	2.70	1.00	0.00	0.00	0.00	-0.1880

AVERAGE RETURN	:	0.1021
VARIANCE OF RETURN	:	0.0636
STANDARD DEVIATION	:	0.2522
ALPHA COEFFICIENT	:	0.0023
BETA COEFFICIENT	:	0.9282

THE HONGKONG AND SHANGHAI HOTELS LIMITED 11

HK HOTEL HOTEL

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	13.30	1.00	0.00	1.30	0.00	-0.0988
2	68	II	16.40	1.00	0.00	0.00	0.00	0.2331
3	68	III	22.20	1.00	0.00	0.40	0.00	0.3780
4	68	IV	29.90	1.00	0.00	0.00	0.00	0.3468
5	69	I	29.00	1.00	0.00	1.60	0.00	0.0234
6	69	II	36.75	1.00	0.00	0.00	0.00	0.2672
7	69	III	52.50	1.00	0.00	0.00	0.00	0.4286
8	69	IV	64.50	1.00	0.00	0.70	0.00	0.2419
9	70	I	69.00	1.00	0.00	0.00	0.00	0.0698
10	70	II	70.00	1.00	0.00	2.80	0.63	0.0642
11	70	III	77.50	1.00	0.00	0.00	0.00	0.1071
12	70	IV	29.70	1.00	2.00	0.90	0.00	0.1613
13	71	I	27.40	1.00	0.00	0.00	0.00	-0.0774
14	71	II	33.50	1.00	0.00	1.23	0.00	0.2675
15	71	III	49.00	1.00	0.00	0.00	0.00	0.4627
16	71	IV	49.00	1.00	0.00	0.35	0.00	0.0071
17	72	I	52.00	1.00	0.00	0.00	0.00	0.0612
18	72	II	62.00	1.00	0.00	1.35	0.55	0.2288
19	72	III	69.00	1.00	0.00	0.00	0.00	0.1129
20	72	IV	145.00	1.00	0.00	0.35	0.00	1.1065
21	73	I	236.00	1.00	0.00	0.00	0.00	0.6276
22	73	II	16.70	3.00	1.00	1.45	0.00	-0.5693
23	73	III	13.50	1.00	0.00	0.00	0.00	-0.1916
24	73	IV	12.75	1.00	0.00	0.07	0.00	-0.0504

AVERAGE RETURN : 0.1754

VARIANCE OF RETURN : 0.0997

STANDARD DEVIATION : 0.3157

ALPHA COEFFICIENT : 0.0449

BETA COEFFICIENT : 1.2128

CITY HOTELS LIMITED

CITY HOTEL HOTEL

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	5.40	1.00	0.00	0.00	0.00	-0.1360
2	68	II	6.75	1.00	0.00	0.30	0.00	0.3056
3	68	III	9.25	1.00	0.00	0.00	0.00	0.3704
4	68	IV	11.80	1.00	0.00	0.40	0.00	0.3189
5	69	I	12.70	1.00	0.00	0.00	0.00	0.0763
6	69	II	16.00	1.00	0.00	0.60	0.00	0.3071
7	69	III	21.60	1.00	0.00	0.00	0.00	0.3500
8	69	IV	22.00	1.00	0.00	0.60	0.00	0.0463
9	70	I	29.50	1.00	0.00	0.00	0.00	0.3409
10	70	II	31.75	1.00	0.00	0.80	0.00	0.1034
11	70	III	28.90	1.00	0.00	0.00	0.00	-0.0898
12	70	IV	27.70	1.00	0.00	0.80	0.00	-0.0138
13	71	I	23.50	1.00	0.00	0.00	0.00	-0.1516
14	71	II	24.60	1.00	0.00	0.90	0.00	0.0851
15	71	III	22.00	1.00	0.00	0.00	0.00	-0.1057
16	71	IV	27.20	1.00	0.00	0.90	0.00	0.2773
17	72	I	28.20	1.00	0.00	0.00	0.00	0.0368
18	72	II	42.00	1.00	0.00	0.90	0.00	0.5213
19	72	III	44.00	1.00	0.00	0.00	0.00	0.0476
20	72	IV	76.00	1.00	0.00	0.90	0.00	0.7477
21	73	I	97.00	1.00	0.00	0.00	0.00	0.2763
22	73	II	50.00	1.00	0.10	1.20	0.00	-0.4206
23	73	III	32.50	1.00	0.00	0.00	0.00	-0.3500
24	73	IV	31.00	1.00	0.00	1.00	0.00	-0.0154

AVERAGE RETURN	:	0.1220
VARIANCE OF RETURN	:	0.0731
STANDARD DEVIATION	:	0.2704
ALPHA COEFFICIENT	:	0.0282
BETA COEFFICIENT	:	0.8725

CHINA LIGHT AND POWER COMPANY LIMITED 13

C. LIGHT PUBLIC UTILITY

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	15.90	1.00	0.00	0.37	0.00	-0.0315
2	68	II	20.90	1.00	0.00	0.37	0.00	0.3377
3	68	III	24.70	1.00	0.00	0.37	0.00	0.1995
4	68	IV	31.25	1.00	0.00	0.45	0.00	0.2834
5	69	I	21.80	1.00	0.67	0.50	0.00	0.1810
6	69	II	22.30	1.00	0.00	0.30	0.00	0.0367
7	69	III	26.10	1.00	0.00	0.30	0.00	0.1839
8	69	IV	27.40	1.00	0.00	0.35	0.00	0.0632
9	70	I	28.80	1.00	0.00	0.30	0.00	0.0620
10	70	II	32.00	1.00	0.00	0.30	0.00	0.1215
11	70	III	35.00	1.00	0.00	0.30	0.00	0.1031
12	70	IV	35.25	1.00	0.00	0.35	0.00	0.0171
13	71	I	35.75	1.00	0.00	0.32	0.00	0.0233
14	71	II	55.50	1.00	0.00	0.32	0.00	0.5614
15	71	III	65.00	1.00	0.00	0.32	0.00	0.1769
16	71	IV	38.75	1.00	0.30	0.43	1.37	-0.1972
17	72	I	36.75	1.00	0.00	0.27	0.00	-0.0446
18	72	II	43.00	1.00	0.00	0.27	0.00	0.1774
19	72	III	41.50	1.00	0.00	0.27	0.00	-0.0286
20	72	IV	54.50	1.00	0.00	0.35	0.00	0.3217
21	73	I	73.00	1.00	0.00	0.30	0.00	0.3450
22	73	II	45.00	1.00	0.00	0.30	0.00	-0.3795
23	73	III	38.00	1.00	0.00	0.30	0.00	-0.1489
24	73	IV	49.60	1.00	0.45	0.40	0.90	-0.2179

AVERAGE RETURN : 0.0894

VARIANCE OF RETURN : 0.0435

STANDARD DEVIATION : 0.2086

ALPHA COEFFICIENT : 0.0103

BETA COEFFICIENT : 0.7355

HONG KONG TELEPHONE COMPANY LIMITED 14

HK TEL. PUBLIC UTILITY

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	18.60	1.00	0.00	0.00	0.00	-0.1058
2	68	II	21.50	1.00	0.00	1.25	0.00	0.2231
3	68	III	25.70	1.00	0.00	0.00	0.00	0.1953
4	68	IV	28.40	1.00	0.00	0.50	0.00	0.1245
5	69	I	26.80	1.00	0.08	0.00	0.88	0.0530
6	69	II	26.30	1.00	0.00	1.25	0.00	0.0280
7	69	III	29.70	1.00	0.00	0.00	0.00	0.1293
8	69	IV	31.75	1.00	0.00	0.60	0.00	0.0892
9	70	I	36.00	1.00	0.00	0.00	0.00	0.1339
10	70	II	41.00	1.00	0.00	1.25	0.00	0.1736
11	70	III	45.00	1.00	0.00	0.00	0.00	0.0976
12	70	IV	49.25	1.00	0.00	0.60	0.00	0.1078
13	71	I	25.50	1.00	1.00	0.00	1.10	0.0579
14	71	II	38.50	1.00	0.00	0.70	0.00	0.5373
15	71	III	47.75	1.00	0.00	0.00	0.00	0.2403
16	71	IV	45.25	1.00	0.00	0.35	0.00	-0.0450
17	72	I	46.25	1.00	0.00	0.00	0.00	0.0221
18	72	II	56.00	1.00	0.00	0.75	0.00	0.2270
19	72	III	54.00	1.00	0.00	0.00	0.00	-0.0357
20	72	IV	71.00	1.00	0.00	0.35	0.00	0.3213
21	73	I	77.50	1.00	0.00	0.00	0.00	0.0915
22	73	II	46.00	1.00	0.00	0.85	0.00	-0.3955
23	73	III	39.00	1.00	0.00	0.00	0.00	-0.1522
24	73	IV	30.15	1.00	0.00	0.35	0.00	-0.2179

AVERAGE RETURN : 0.0792

VARIANCE OF RETURN : 0.0350

STANDARD DEVIATION : 0.1871

ALPHA COEFFICIENT : 0.0093

BETA COEFFICIENT : 0.6500

THE HONG KONG AND CHINA GAS COMPANY LIMITED 15

HK GAS PUBLIC UTILITY

PERIOD	QUARTER YEARLY	MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68 I	10.80	1.00	0.00	0.00	0.00	-0.0182
2	68 II	11.30	1.00	0.00	0.50	0.00	0.0926
3	68 III	13.00	1.00	0.00	0.00	0.00	0.1504
4	68 IV	12.90	1.00	0.00	0.50	0.00	0.0308
5	69 I	12.50	1.00	0.00	0.00	0.00	-0.0310
6	69 II	13.00	1.00	0.00	0.50	0.00	0.0800
7	69 III	14.80	1.00	0.00	0.00	0.00	0.1385
8	69 IV	14.20	1.00	0.00	0.50	0.00	-0.0068
9	70 I	14.80	1.00	0.00	0.00	0.00	0.0423
10	70 II	16.00	1.00	0.00	0.50	0.00	0.1149
11	70 III	16.20	1.00	0.00	0.00	0.00	0.0125
12	70 IV	17.90	1.00	0.00	0.50	0.00	0.1358
13	71 I	17.60	1.00	0.00	0.00	0.00	-0.0168
14	71 II	19.60	1.00	0.00	0.60	0.76	0.1909
15	71 III	27.00	1.00	0.00	0.00	0.00	0.3776
16	71 IV	25.50	1.00	0.00	0.50	0.00	-0.0370
17	72 I	25.50	1.00	0.00	0.00	0.00	0.0000
18	72 II	29.50	1.00	0.00	0.60	0.00	0.1804
19	72 III	39.00	1.00	0.00	0.00	0.00	0.3220
20	72 IV	47.00	1.00	0.00	0.50	0.00	0.2179
21	73 I	65.00	1.00	0.00	0.00	0.00	0.3830
22	73 II	18.30	1.00	1.00	0.70	0.00	-0.4262
23	73 III	12.40	1.00	0.00	0.00	0.00	-0.3224
24	73 IV	11.00	1.00	0.00	0.30	0.00	-0.0887

AVERAGE RETURN : 0.0634

VARIANCE OF RETURN : 0.0348

STANDARD DEVIATION : 0.1866

ALPHA COEFFICIENT : 0.0006

BETA COEFFICIENT : 0.5844

LANE, CRAWFORD LIMITED 16

L. CRAW FOOD & STORE

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	19.00	1.00	0.00	0.00	0.00	-0.0732
2	68	II	23.70	1.00	0.00	0.00	0.00	0.2474
3	68	III	28.90	1.00	0.00	2.00	0.00	0.3038
4	68	IV	33.50	1.00	0.00	0.50	0.00	0.1765
5	69	I	35.00	1.00	0.00	0.00	1.25	0.0821
6	69	II	42.25	1.00	0.00	0.00	0.00	0.2071
7	69	III	45.75	1.00	0.00	2.00	0.00	0.1302
8	69	IV	45.25	1.00	0.00	1.00	0.00	0.0109
9	70	I	51.50	1.00	0.00	0.00	0.00	0.1381
10	70	II	58.50	1.00	0.00	0.00	0.00	0.1359
11	70	III	27.60	1.00	1.00	2.50	0.00	-0.0137
12	70	IV	28.00	1.00	0.00	0.50	0.00	0.0326
13	71	I	27.20	1.00	0.00	0.00	0.00	-0.0286
14	71	II	32.00	1.00	0.00	0.00	0.00	0.1765
15	71	III	34.00	1.00	0.00	1.00	0.00	0.0938
16	71	IV	32.00	1.00	0.00	0.50	0.00	-0.0441
17	72	I	31.00	1.00	0.00	0.00	0.00	-0.0313
18	72	II	40.50	1.00	0.00	0.00	0.00	0.3065
19	72	III	30.00	1.00	0.00	1.00	1.25	-0.2037
20	72	IV	40.50	1.00	0.00	0.50	0.00	0.3667
21	73	I	87.00	1.00	0.00	0.00	0.00	1.1481
22	73	II	31.00	1.00	0.00	0.00	0.00	-0.6437
23	73	III	22.30	1.00	0.00	1.00	0.00	-0.2484
24	73	IV	18.20	1.00	0.00	0.50	0.00	-0.1614

AVERAGE RETURN : 0.0878

VARIANCE OF RETURN : 0.0976

STANDARD DEVIATION : 0.3124

ALPHA COEFFICIENT : -0.0171

BETA COEFFICIENT : 0.9755

JARDINE, MATHESON AND COMPANY LIMITED 17

JARDINE COMMERCE

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	11.80	1.00	0.00	0.00	0.00	-0.0084
2	68	II	13.60	1.00	0.00	0.30	0.00	0.1780
3	68	III	18.60	1.00	0.00	0.00	0.00	0.3676
4	68	IV	23.70	1.00	0.00	0.20	0.00	0.2849
5	69	I	31.75	1.00	0.00	0.00	0.00	0.3397
6	69	II	32.50	1.00	0.14	0.32	0.00	0.1801
7	69	III	42.00	1.00	0.00	0.00	0.00	0.2923
8	69	IV	42.25	1.00	0.00	0.30	0.00	0.0131
9	70	I	46.25	1.00	0.00	0.00	0.00	0.0947
10	70	II	47.00	1.00	0.00	0.47	0.00	0.0264
11	70	III	53.00	1.00	0.00	0.00	0.00	0.1277
12	70	IV	31.75	1.00	1.00	0.70	0.00	0.2113
13	71	I	33.25	1.00	0.00	0.00	0.00	0.0472
14	71	II	51.50	1.00	0.00	0.35	0.00	0.5594
15	71	III	50.00	1.00	0.00	0.00	0.00	-0.0291
16	71	IV	50.00	1.00	0.10	0.40	0.00	0.1030
17	72	I	56.00	1.00	0.00	0.00	0.00	0.1200
18	72	II	67.50	1.00	0.20	0.80	0.00	0.4607
19	72	III	74.50	1.00	0.00	0.00	0.00	0.1037
20	72	IV	137.00	1.00	0.50	0.45	0.00	1.7644
21	73	I	204.00	1.00	0.00	0.00	0.00	0.4891
22	73	II	72.00	1.00	0.40	0.70	0.00	-0.5025
23	73	III	72.00	1.00	0.00	0.00	0.00	0.0000
24	73	IV	28.40	1.00	1.00	0.30	0.00	-0.2069

AVERAGE RETURN : 0.2092

VARIANCE OF RETURN : 0.1615

STANDARD DEVIATION : 0.4019

ALPHA COEFFICIENT : 0.0522

BETA COEFFICIENT : 1.4603

WHEELOCK MARDEN AND COMPANY LIMITED

WHEELOCK COMMERCE

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	5.30	1.00	0.00	0.00	0.00	-0.1654
2	68	II	6.45	1.00	0.00	0.25	0.00	0.2642
3	68	III	8.00	1.00	0.00	0.00	0.00	0.2403
4	68	IV	9.25	1.00	0.00	0.35	0.00	0.2000
5	69	I	10.60	1.00	0.00	0.00	0.00	0.1459
6	69	II	10.50	1.00	0.00	0.25	1.17	0.1245
7	69	III	12.70	1.00	0.00	0.00	0.00	0.2095
8	69	IV	11.30	1.00	0.00	0.40	0.00	-0.0787
9	70	I	12.50	1.00	0.00	0.00	0.00	0.1062
10	70	II	12.50	1.00	0.00	0.30	1.12	0.1140
11	70	III	13.90	1.00	0.00	0.00	0.00	0.1120
12	70	IV	14.60	1.00	0.00	0.50	0.00	0.0863
13	71	I	14.20	1.00	0.00	0.00	0.00	-0.0274
14	71	II	19.00	1.00	0.00	0.30	0.00	0.3592
15	71	III	23.10	1.00	0.00	0.00	0.00	0.2158
16	71	IV	22.90	1.00	0.10	0.50	0.00	0.1121
17	72	I	24.20	1.00	0.00	0.40	0.50	0.0961
18	72	II	32.00	1.00	0.00	0.00	0.00	0.3223
19	72	III	35.75	1.00	0.00	0.70	0.00	0.1391
20	72	IV	51.50	1.00	0.10	0.20	0.00	0.5902
21	73	I	75.00	1.00	0.00	0.40	0.00	0.4641
22	73	II	45.50	1.00	0.00	0.00	0.00	-0.3933
23	73	III	7.45	5.00	0.10	0.19	0.00	-0.0953
24	73	IV	4.60	1.00	0.00	0.00	0.00	-0.3826

AVERAGE RETURN : 0.1150

VARIANCE OF RETURN : 0.0523

STANDARD DEVIATION : 0.2288

ALPHA COEFFICIENT : 0.0223

BETA COEFFICIENT : 0.8616

A. S. WATSON AND COMPANY LIMITED 19

WATSONS COMMERCE

PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	37.00	1.00	0.00	0.00	0.00	-0.0263
2	68	II	40.50	1.00	0.00	2.50	0.00	0.1622
3	68	III	53.50	1.00	0.00	0.00	0.00	0.3210
4	68	IV	61.50	1.00	0.00	2.00	0.00	0.1869
5	69	I	68.00	1.00	0.00	0.00	0.00	0.1057
6	69	II	72.00	1.00	0.00	3.00	0.00	0.1029
7	69	III	89.00	1.00	0.00	0.00	6.80	0.3306
8	69	IV	87.50	1.00	0.00	2.50	0.00	0.0112
9	70	I	93.00	1.00	0.00	0.00	0.00	0.0629
10	70	II	87.00	1.00	0.00	3.00	0.00	-0.0323
11	70	III	95.00	1.00	0.00	0.00	0.00	0.0920
12	70	IV	103.00	1.00	0.00	3.00	0.00	0.1158
13	71	I	102.00	1.00	0.00	0.00	0.00	-0.0097
14	71	II	80.00	1.00	0.00	3.50	20.00	0.1029
15	71	III	92.00	1.00	0.00	0.00	0.00	0.0337
16	71	IV	77.00	1.00	0.00	2.00	0.00	-0.1413
17	72	I	81.00	1.00	0.00	0.00	0.00	0.0519
18	72	II	78.50	1.00	0.00	2.35	0.00	-0.0019
19	72	III	102.00	1.00	0.00	0.00	0.00	0.2994
20	72	IV	133.00	1.00	0.00	2.25	0.00	0.3260
21	73	I	160.00	1.00	0.00	0.00	0.00	0.2030
22	73	II	23.50	2.00	4.00	2.75	0.00	0.4859
23	73	III	5.80	1.00	0.00	0.00	0.00	-0.7532
24	73	IV	4.80	1.00	0.00	0.25	0.00	-0.1293

AVERAGE RETURN	:	0.0792
VARIANCE OF RETURN	:	0.0550
STANDARD DEVIATION	:	0.2345
ALPHA COEFFICIENT	:	0.0516
BETA COEFFICIENT	:	0.2563

TEXTILE ALLIANCE LIMITED 20

ALLIANCE TEXTILE

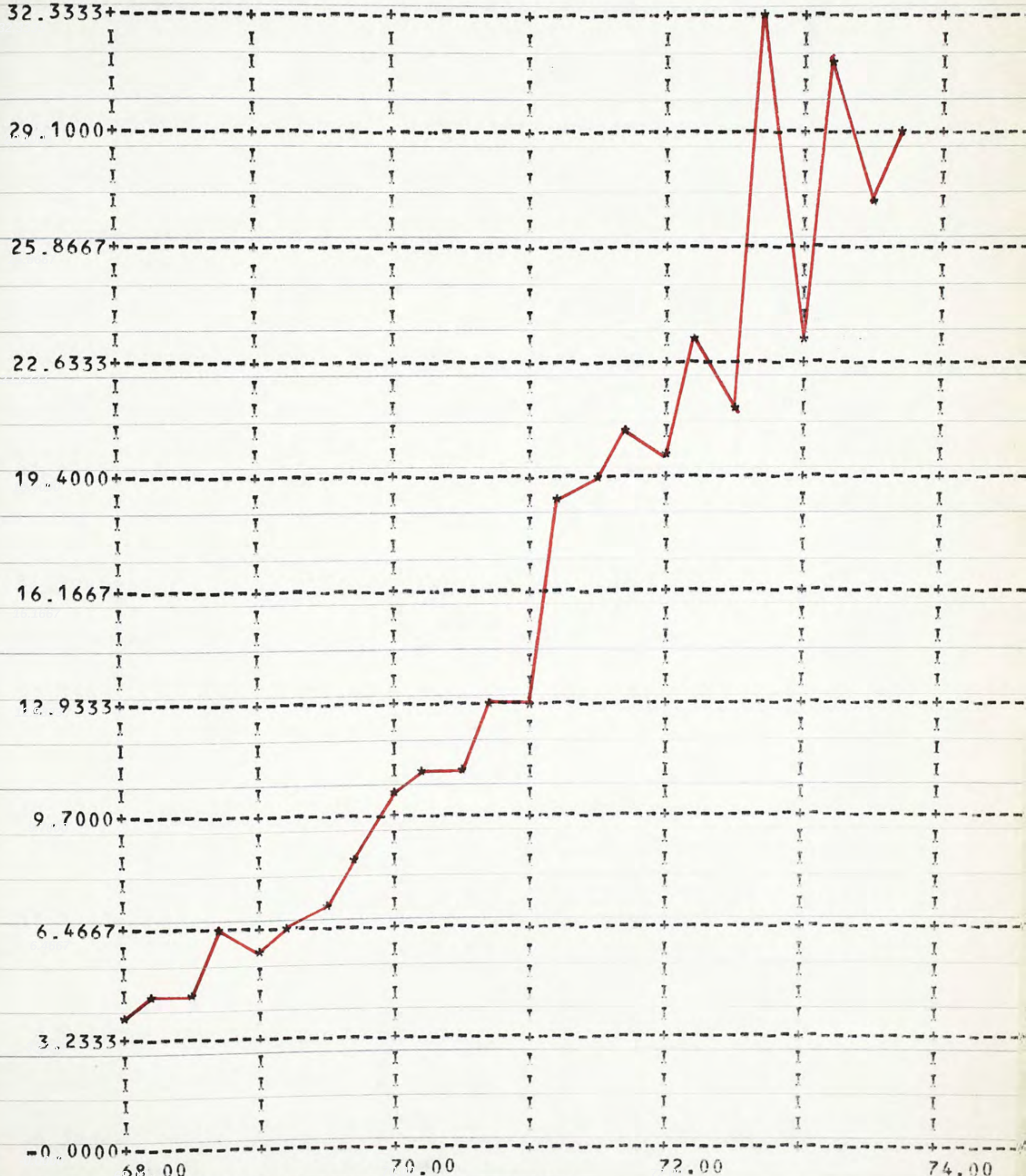
PERIOD	QUARTER YEARLY		MARKET PRICE ($)	STOCK SPLIT	STOCK DIVID	CASH DIVID ($)	PROP DIV OR RTS ISSUED ($)	RETURN ON INVESTMENT
1	68	I	5.60	1.00	0.00	0.40	0.00	0.1765
2	68	II	10.00	1.00	0.00	0.00	0.00	0.7857
3	68	III	17.20	1.00	0.00	0.60	0.00	0.7800
4	68	IV	24.90	1.00	0.00	0.00	0.00	0.4477
5	69	I	26.10	1.00	0.00	0.80	0.00	0.0803
6	69	II	30.25	1.00	0.00	0.00	0.00	0.1590
7	69	III	29.90	1.00	0.00	1.60	0.00	0.0413
8	69	IV	25.30	1.00	0.20	0.00	0.66	0.0375
9	70	I	25.40	1.00	0.00	0.70	0.00	0.0316
10	70	II	22.50	1.00	0.00	0.00	0.00	-0.1142
11	70	III	20.80	1.00	0.00	1.20	0.00	-0.0222
12	70	IV	20.50	1.00	0.00	0.00	0.00	-0.0144
13	71	I	18.20	1.00	0.00	0.30	0.00	-0.0976
14	71	II	21.00	1.00	0.00	0.00	0.00	0.1538
15	71	III	20.00	1.00	0.00	0.70	0.00	-0.0143
16	71	IV	26.00	1.00	0.00	0.00	0.00	0.3000
17	72	I	28.90	1.00	0.00	0.50	0.00	0.1308
18	72	II	41.50	1.00	0.00	0.00	0.00	0.4360
19	72	III	31.50	1.00	0.40	1.00	0.00	0.0867
20	72	IV	44.50	1.00	0.00	0.00	0.00	0.3175
21	73	I	38.50	1.00	0.00	0.40	0.00	-0.0627
22	73	II	34.00	1.00	0.00	0.00	0.00	-0.1169
23	73	III	30.75	1.00	0.00	0.80	1.12	-0.0390
24	73	IV	38.00	1.00	0.00	0.40	0.00	0.2488

AVERAGE RETURN	:	0.1555
VARIANCE OF RETURN	:	0.0629
STANDARD DEVIATION	:	0.2508
ALPHA COEFFICIENT	:	0.1185
BETA COEFFICIENT	:	0.3443

APPENDIX I

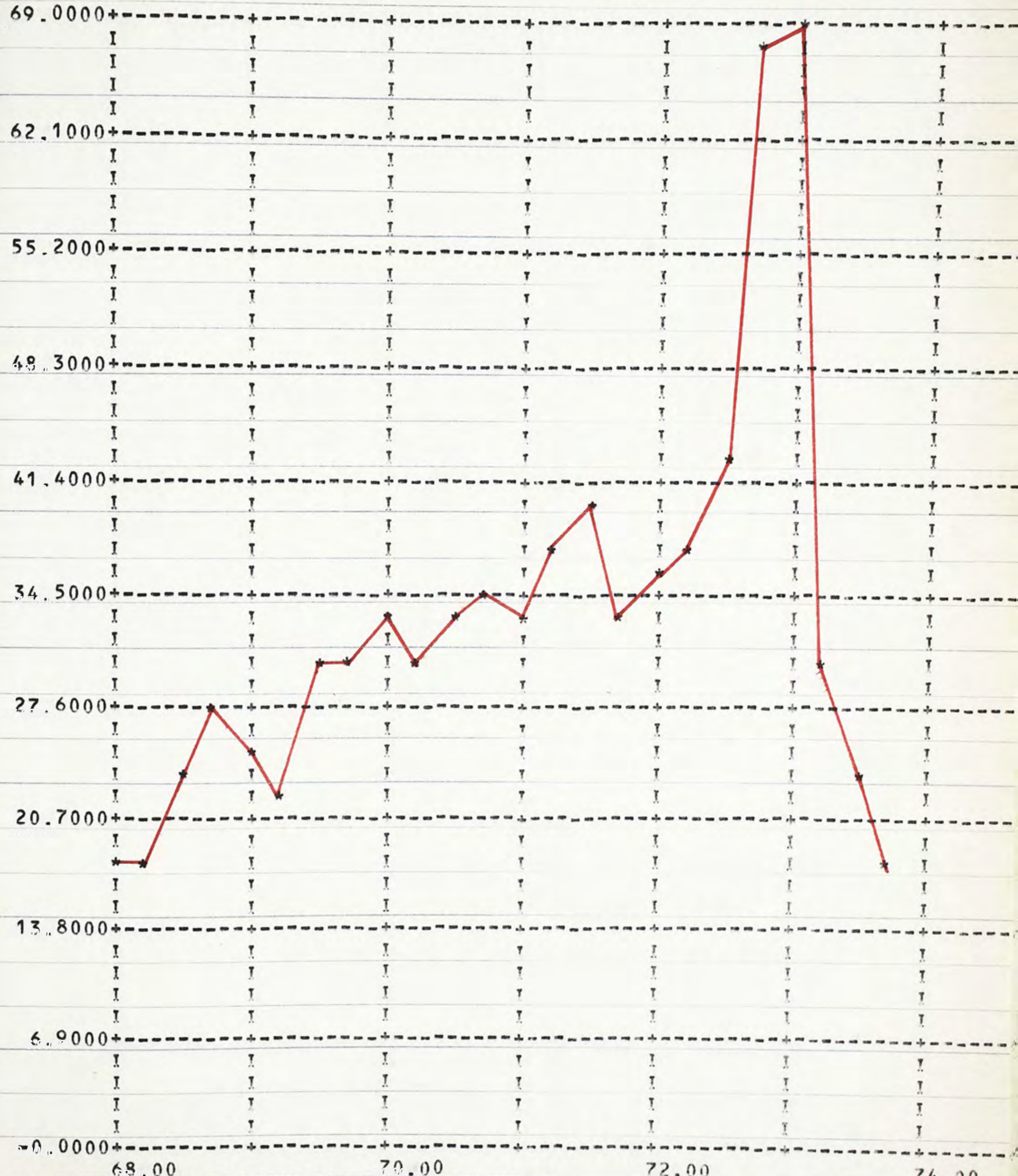
PLOT OF MARKET PRICE (ADJUSTED) AGAINST TIME

FIGURE 1



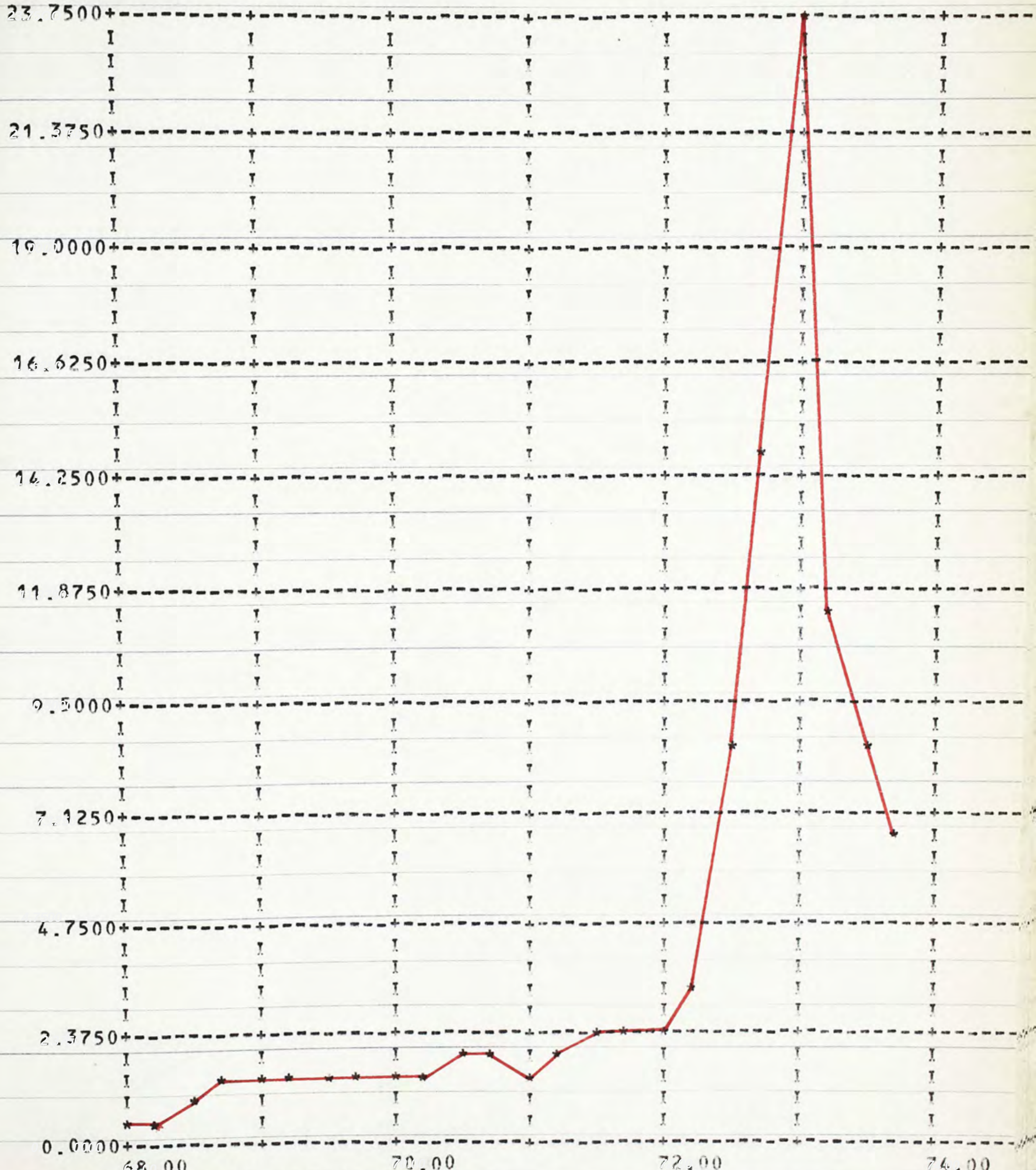
THE HONGKONG AND SHANGHAI BANKING CORPORATION

FIGURE 2



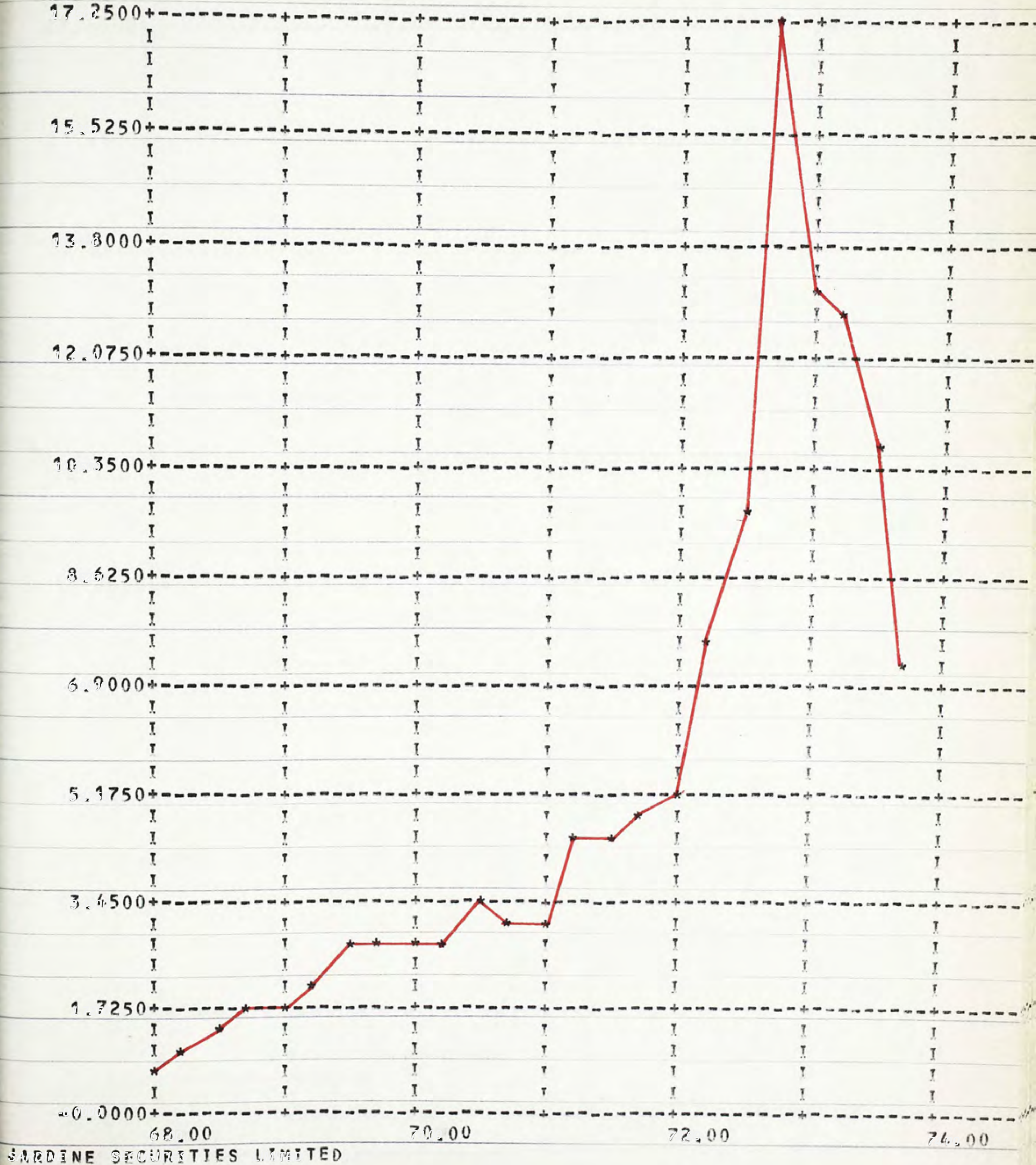
THE HONGKONG AND YAUMATI FERRY COMPANY LIMITED

FIGURE 3



THE KOWLOON MOTOR BUS COMPANY LIMITED

FIGURE 4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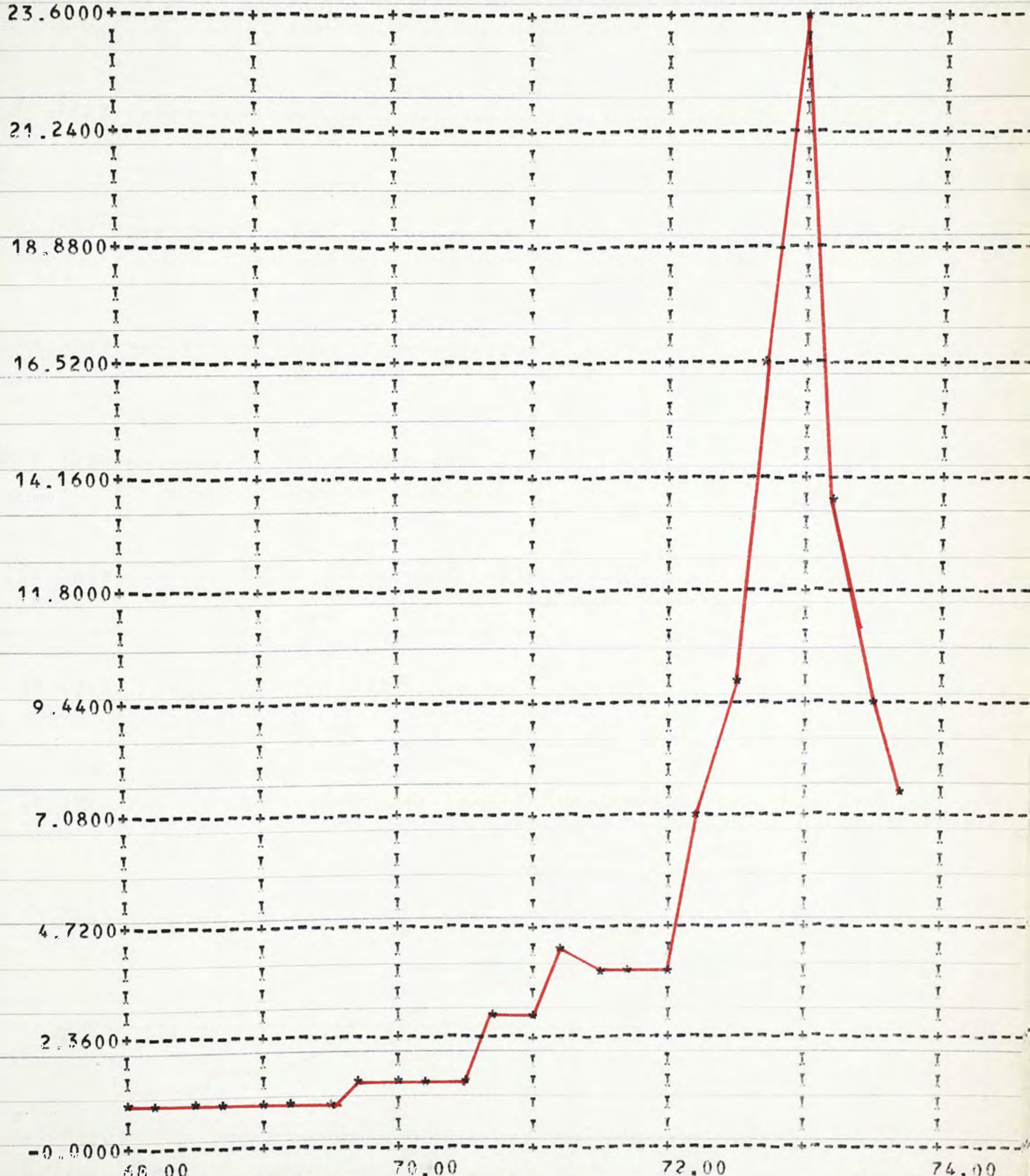
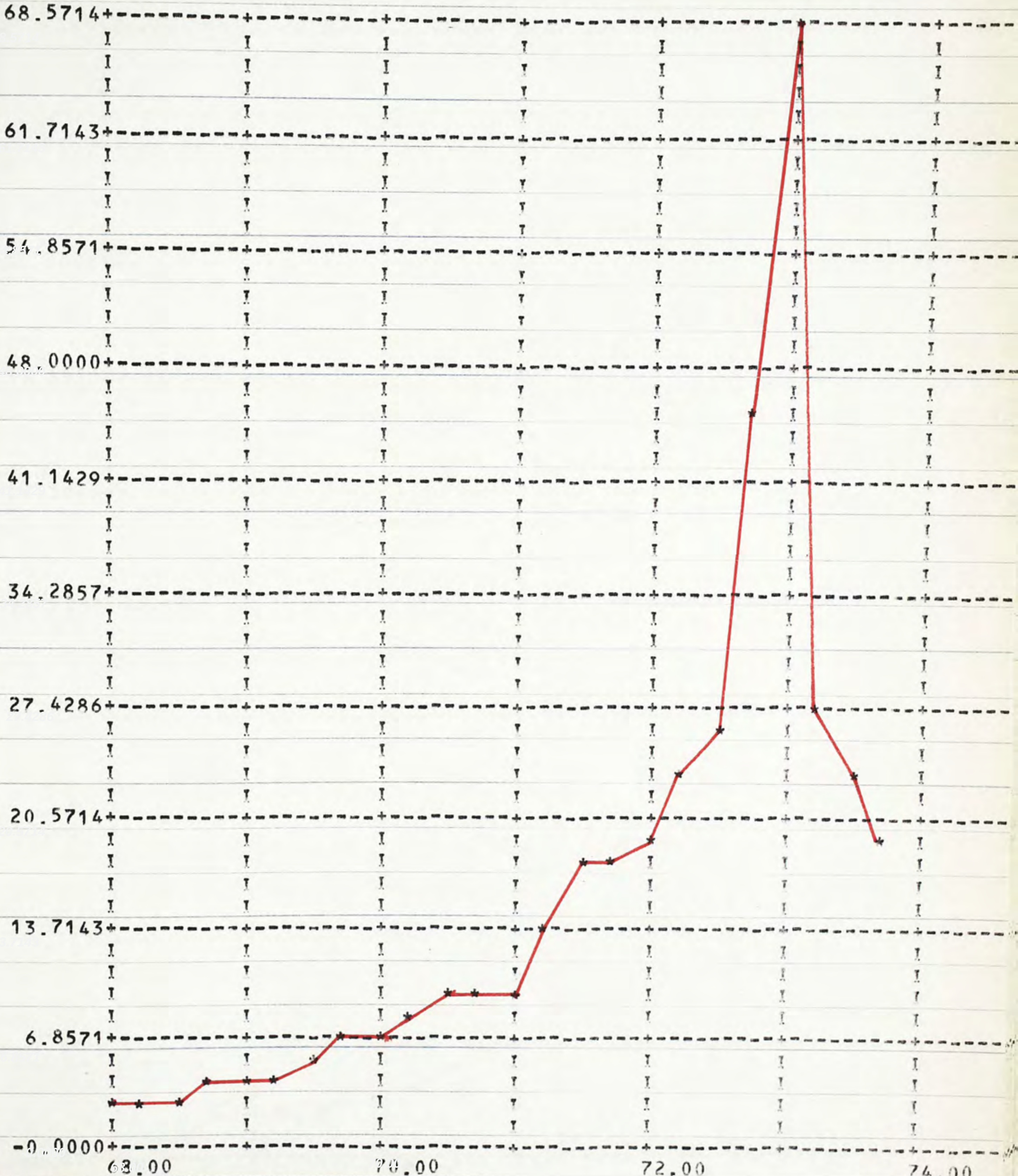
15.5250
13.8000
12.0750
10.3500
8.6250
6.9000
5.1750
3.4500
1.7250
-0.0000
68.00
70.00
72.00
74.00
JARDINE SECURITIES LIMITED

FIGURE 5



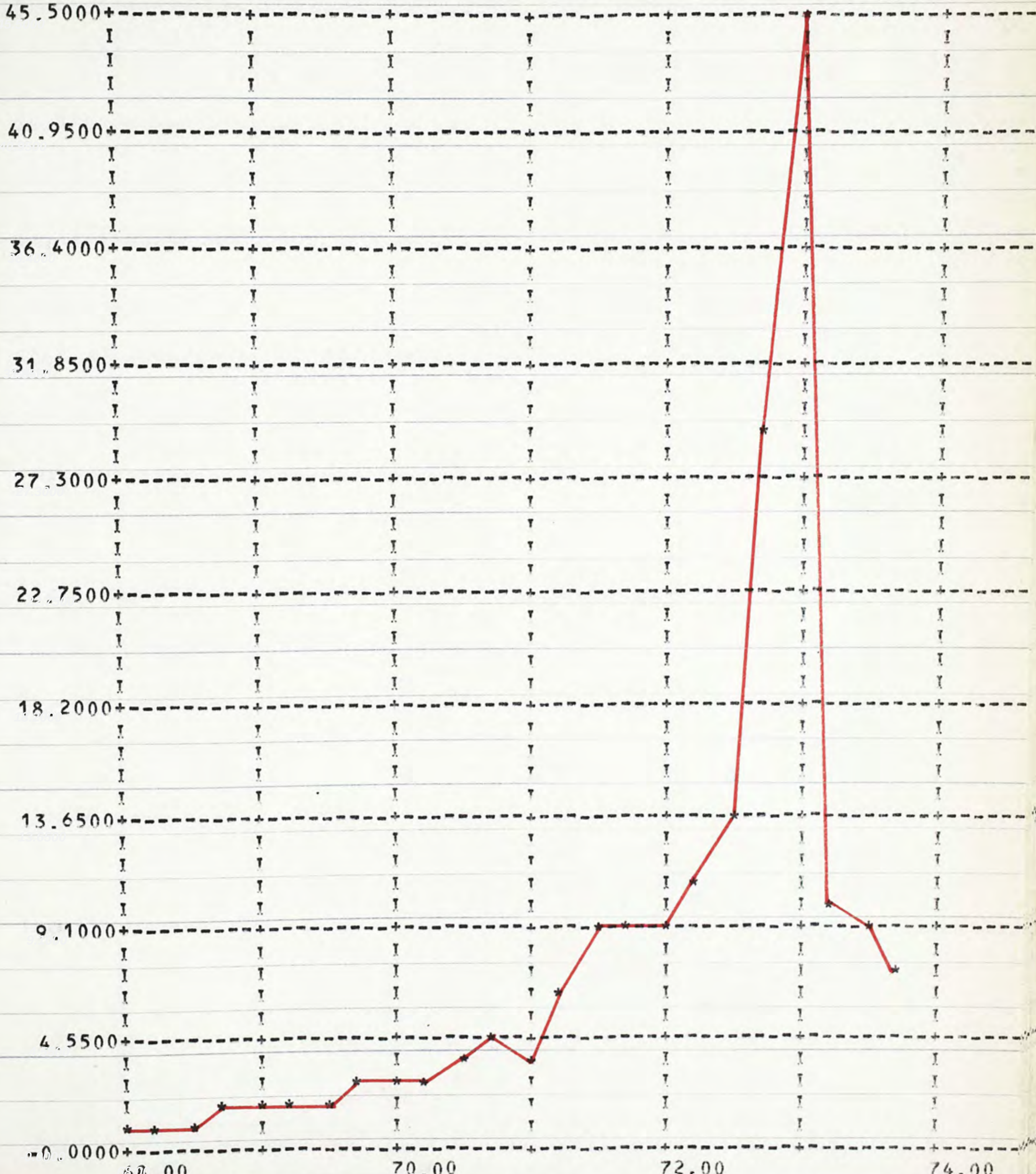
EASTERN ASIA NAVIGATION COMPANY LIMITED

FIGURE 6



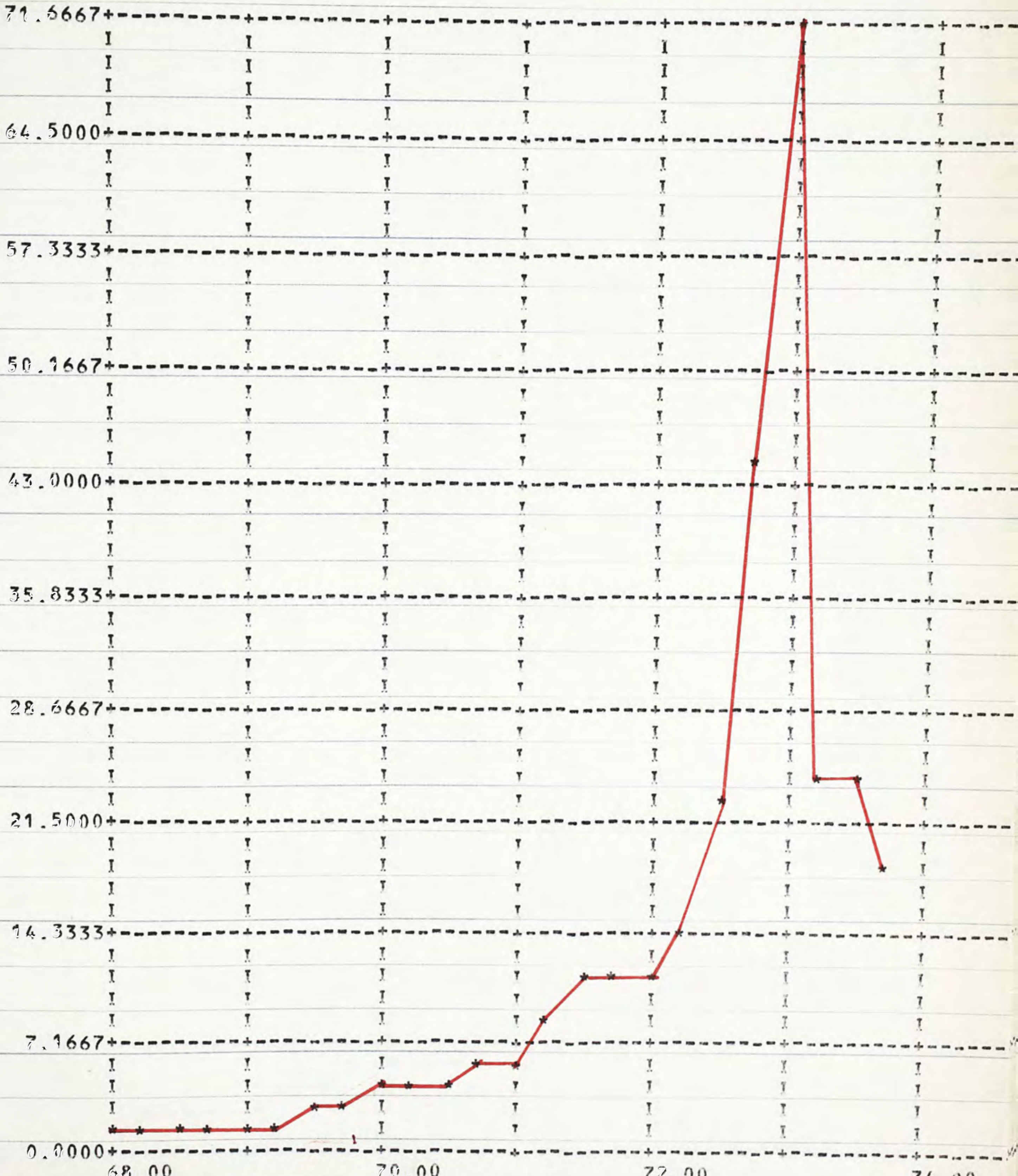
HONGKONG AND WHAMPOA DOCK COMPANY LIMITED

FIGURE 7



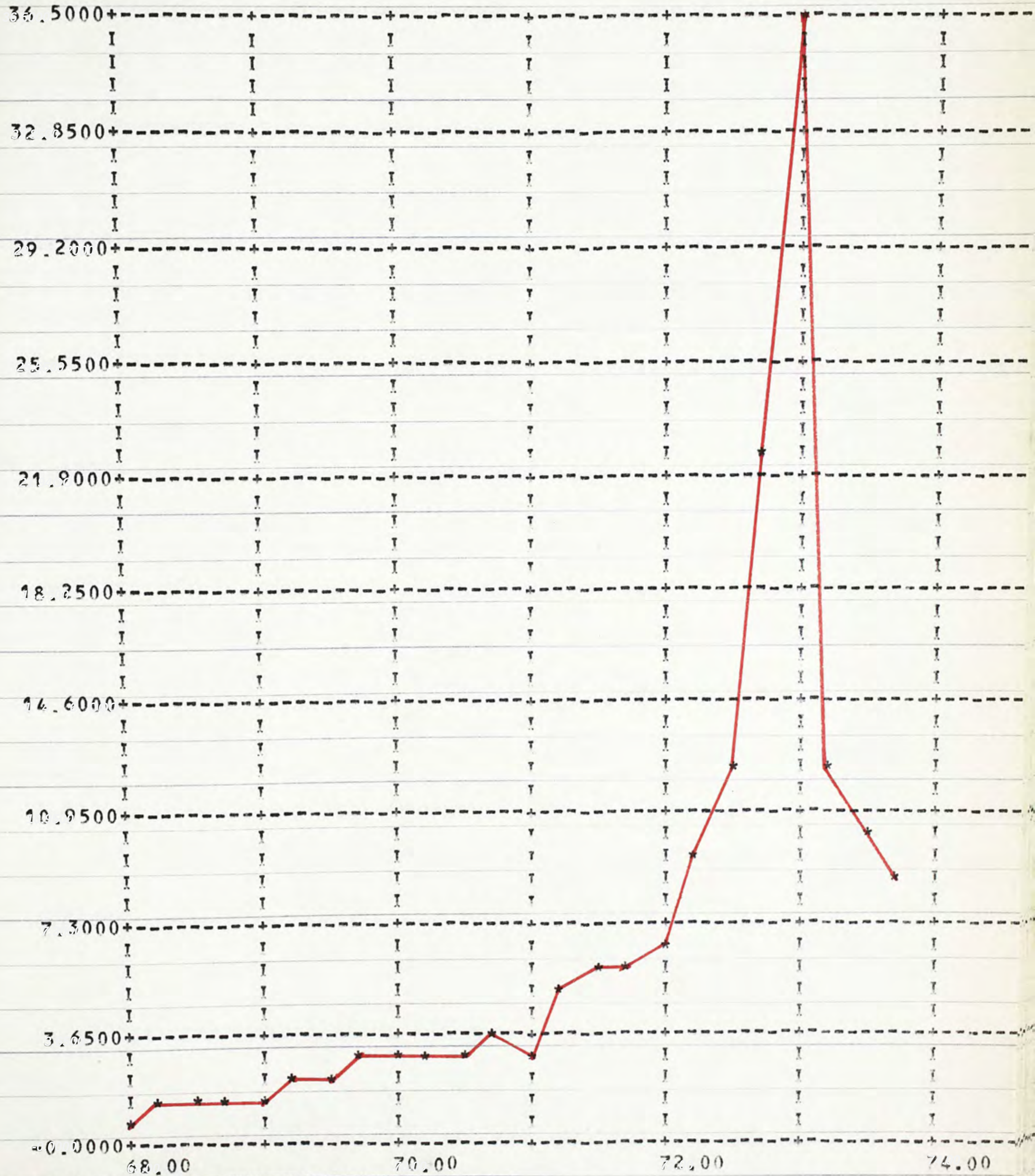
TAIKOO SWIRE LIMITED

FIGURE 8



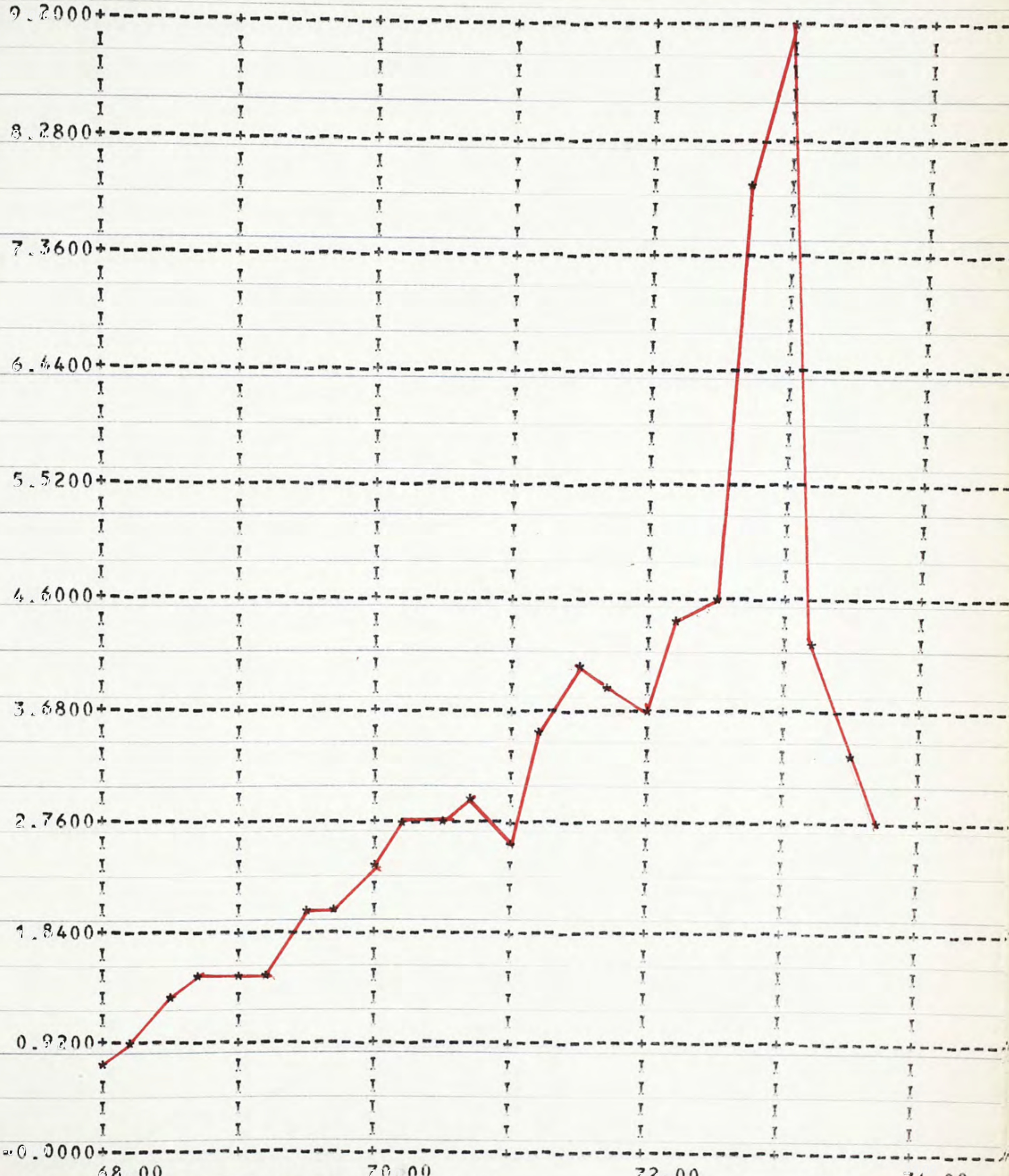
THE HONGKONG AND KOWLOON WHARF AND GODOWN COMPANY LIMITED

FIGURE 9



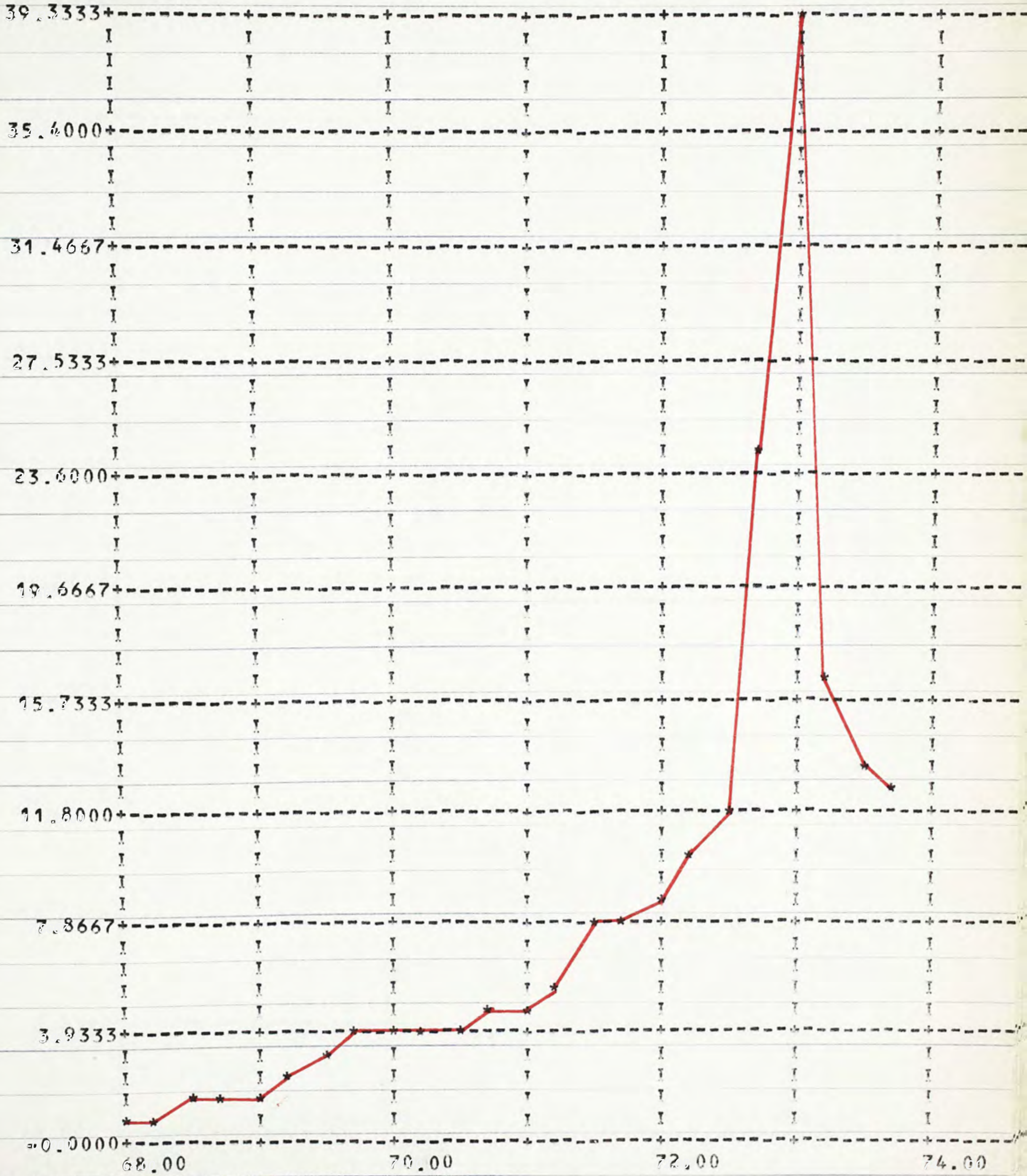
THE HONGKONG LAND COMPANY LIMITED

FIGURE 10



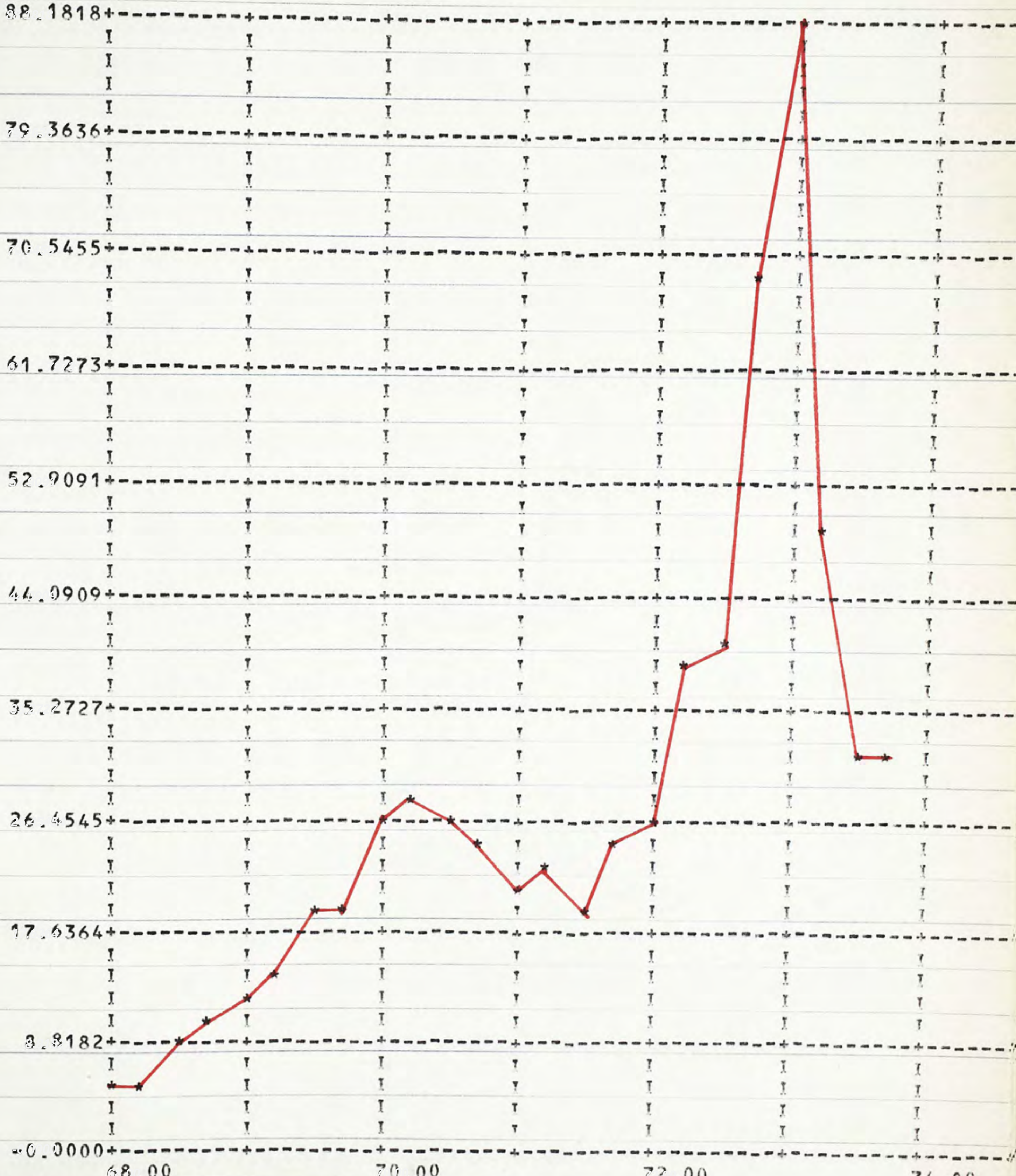
HONGKONG REALTY AND TRUST COMPANY LIMITED

FIGURE 11



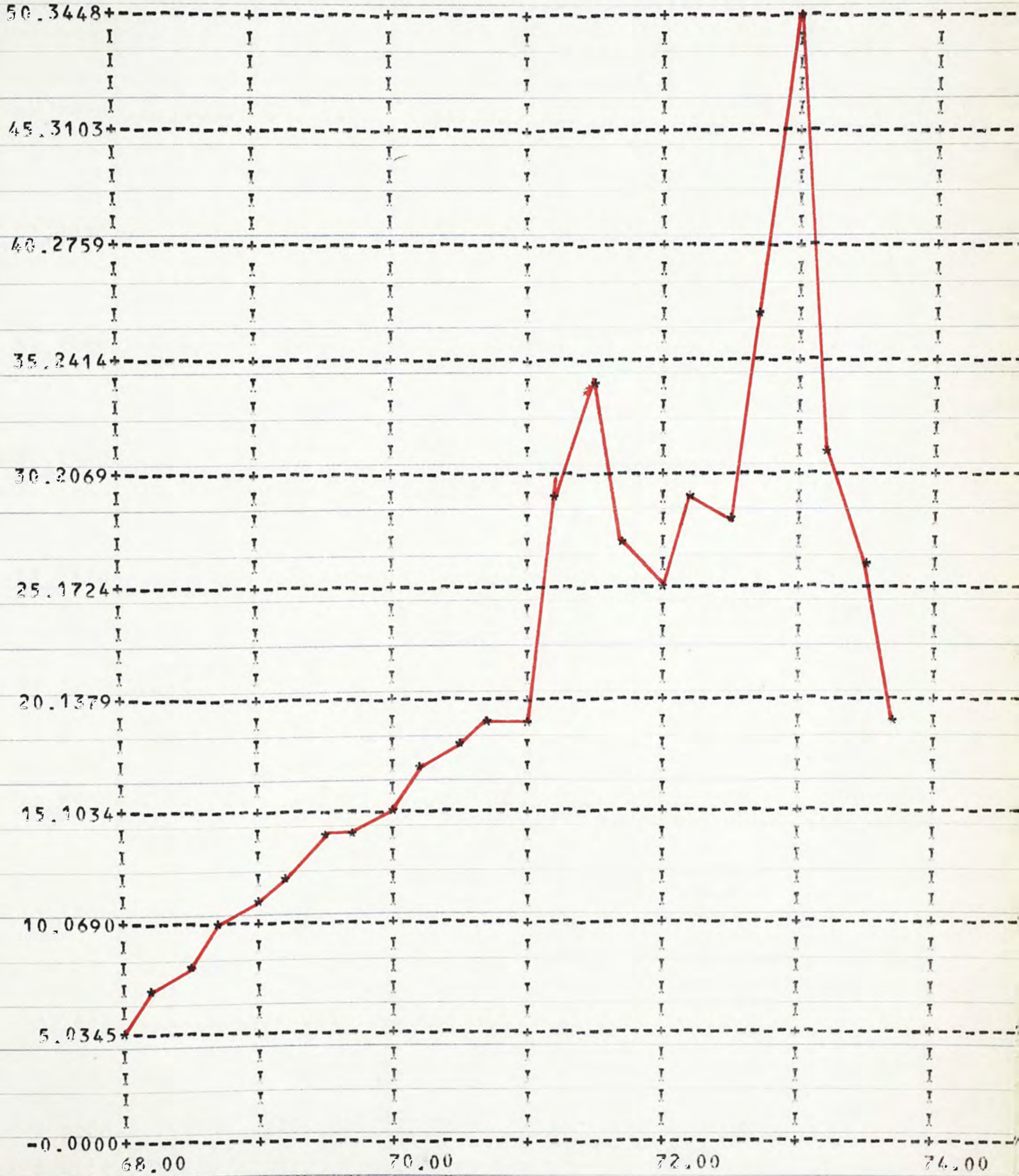
THE HONGKONG AND SHANGHAI HOTELS LIMITED

FIGURE 12



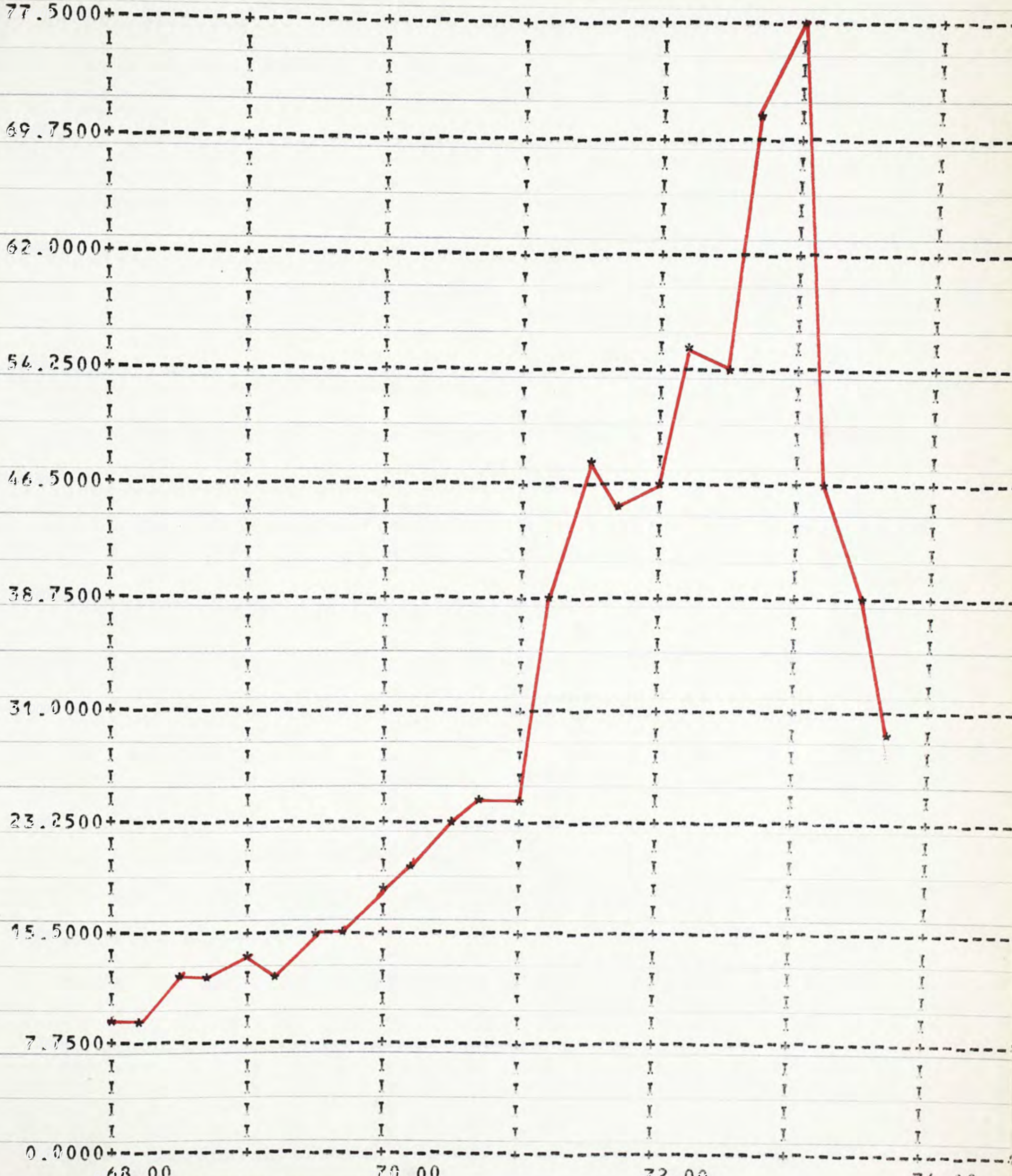
CITY HOTELS LIMITED

FIGURE 13



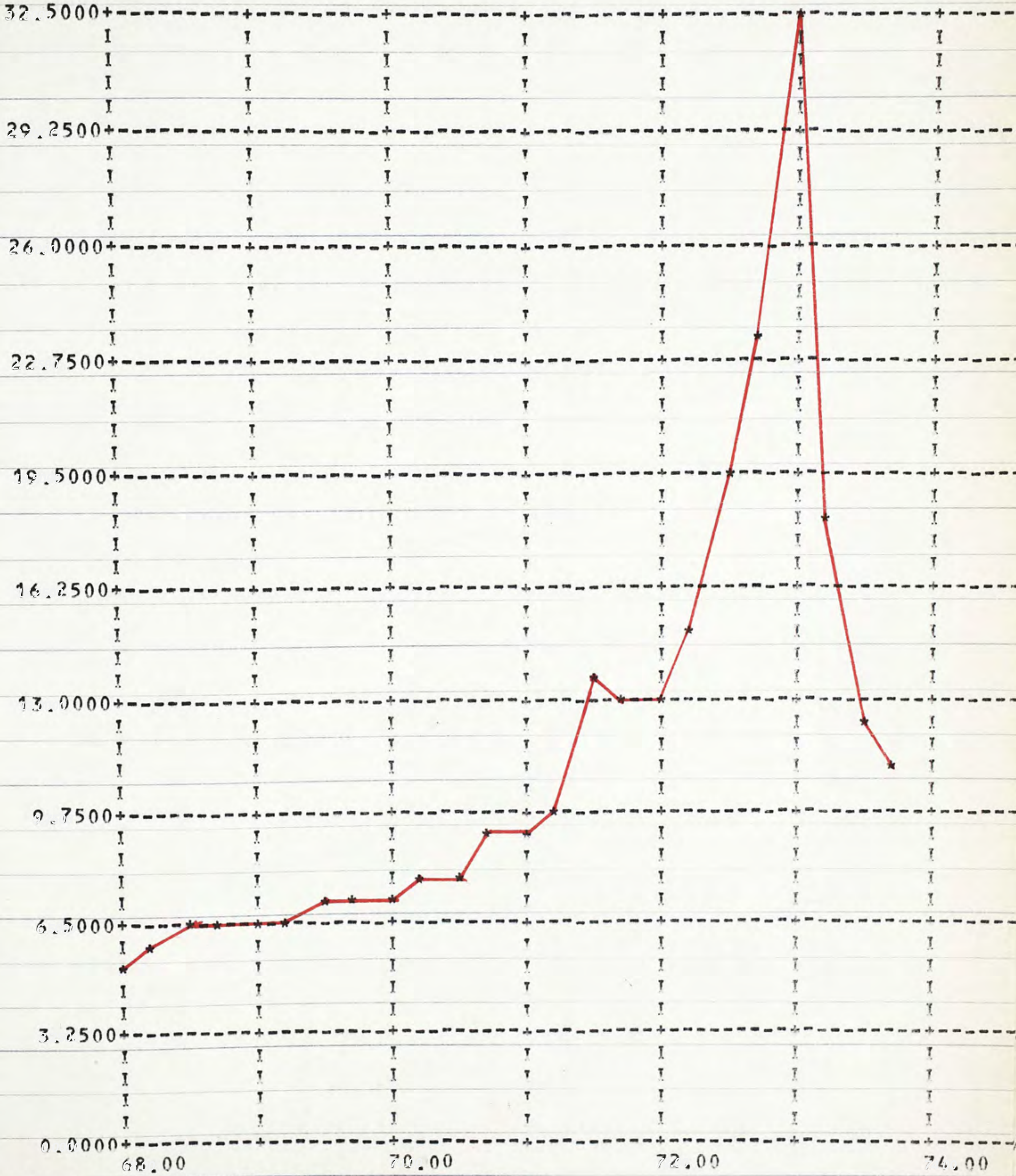
CHINA LIGHT AND POWER COMPANY LIMITED

FIGURE 14



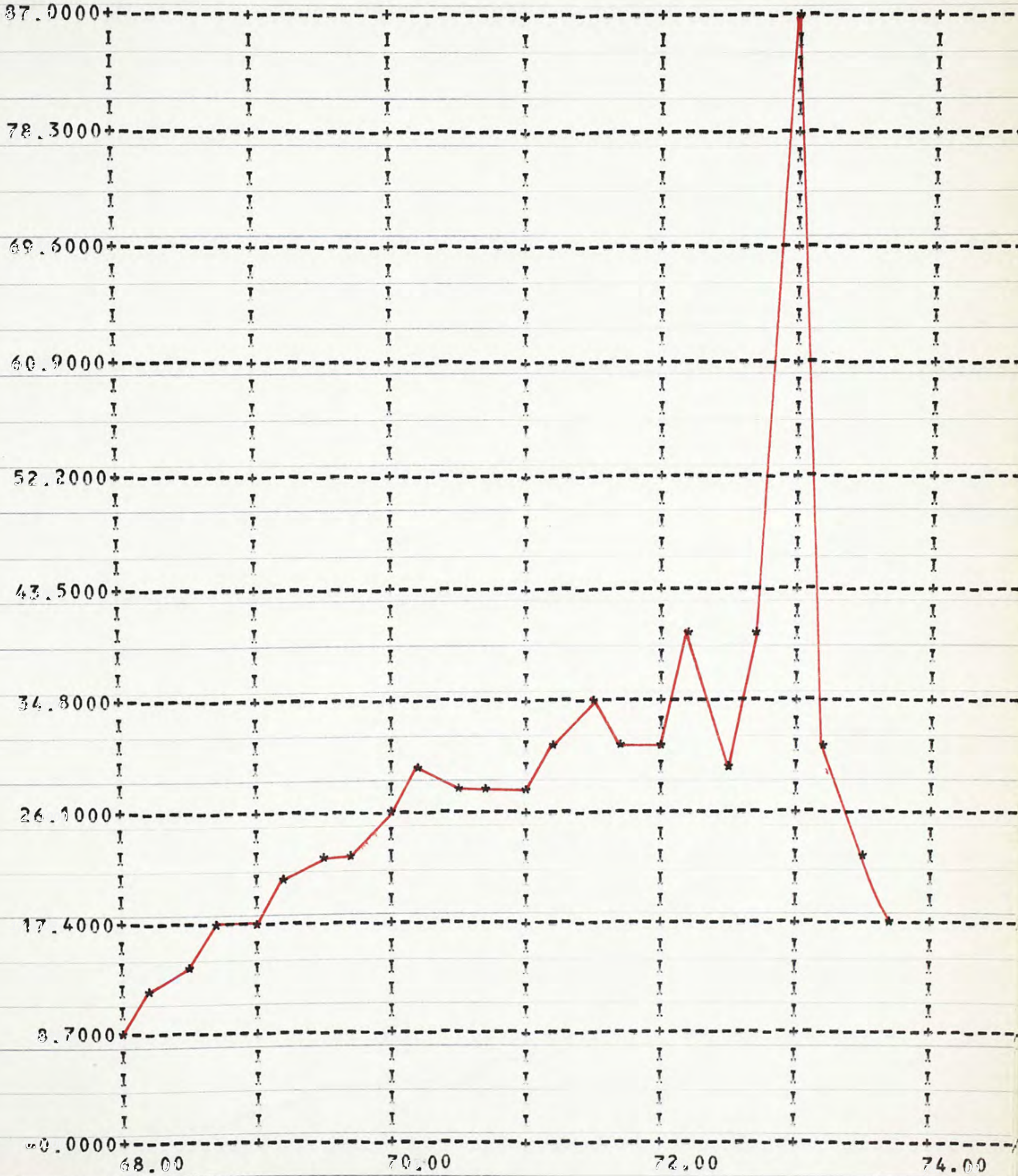
HONG KONG TELEPHONE COMPANY LIMITED

FIGURE 15



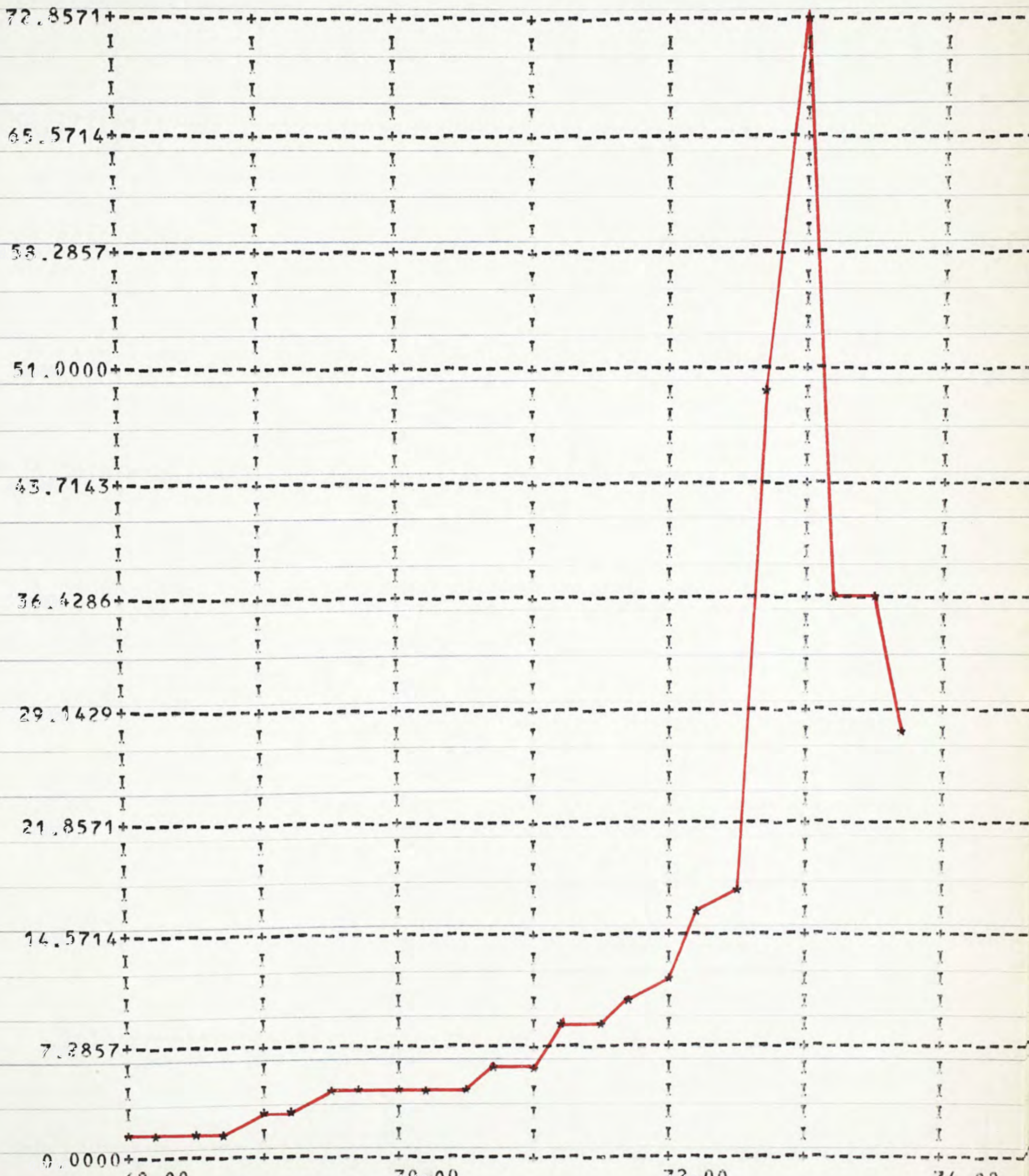
THE HONG KONG AND CHINA GAS COMPANY LIMITED

FIGURE 16



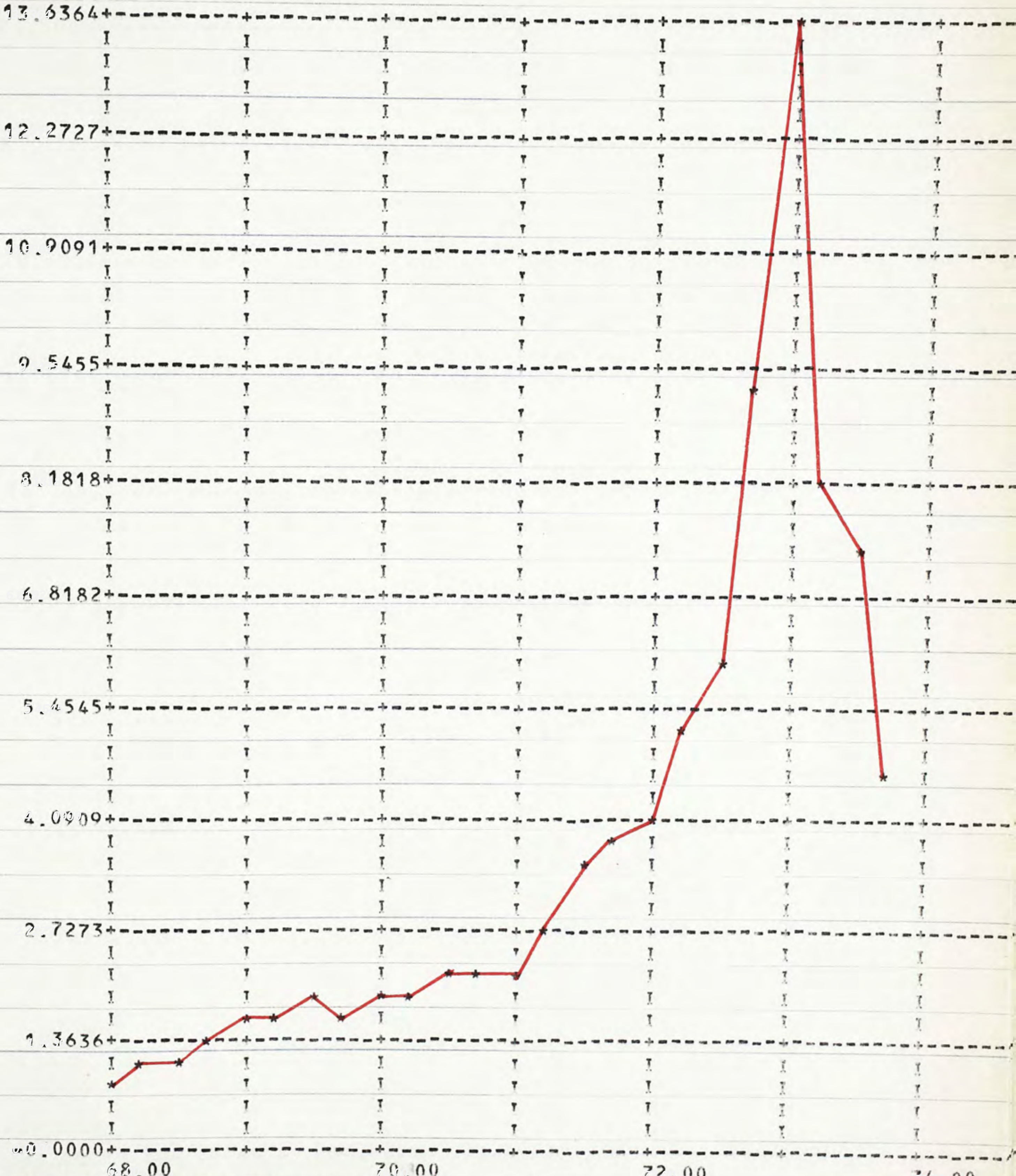
LANE, CRAWFORD LIMITED

FIGURE 17



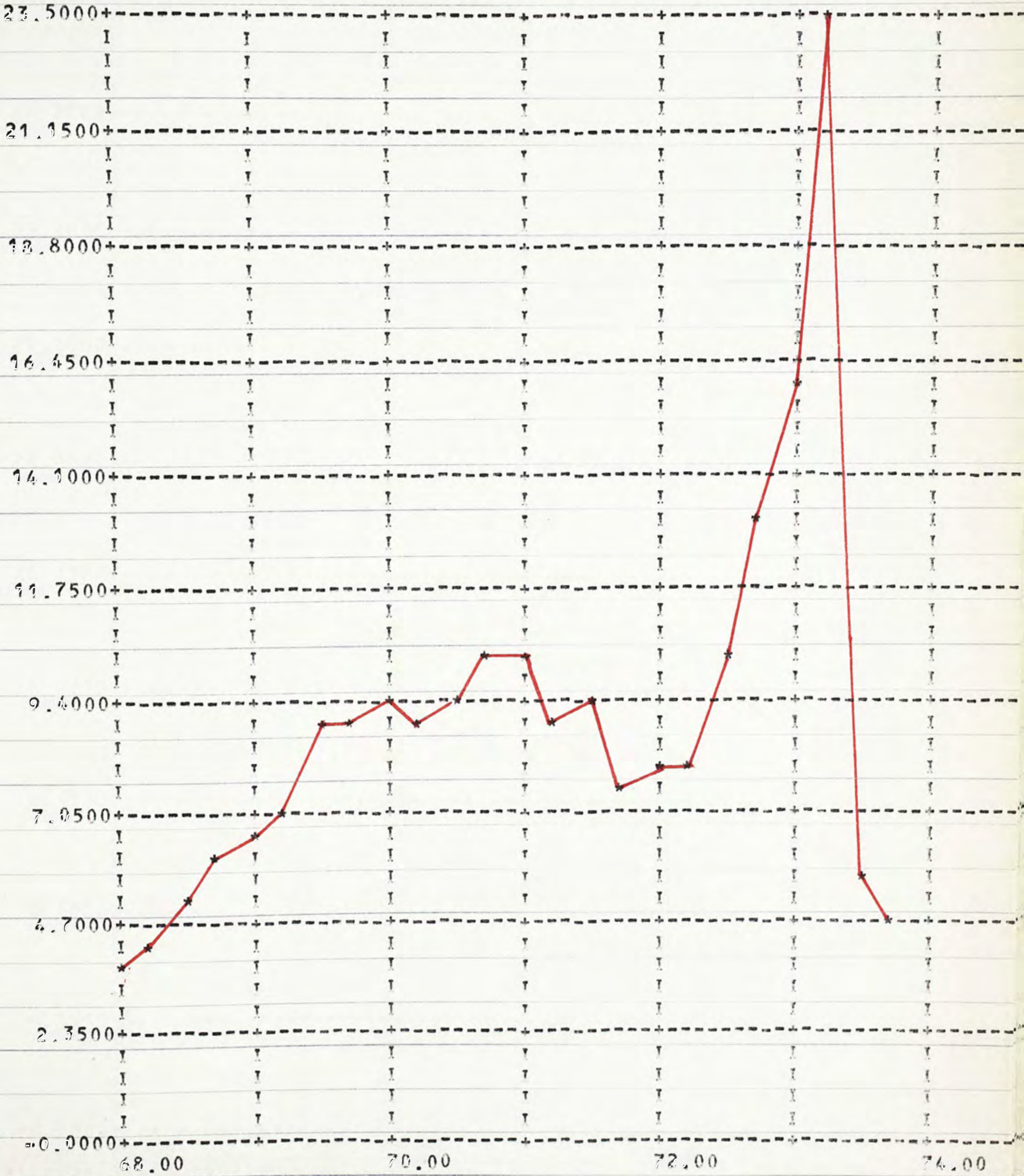
JARDINE, MATHESON AND COMPANY LIMITED

FIGURE 18



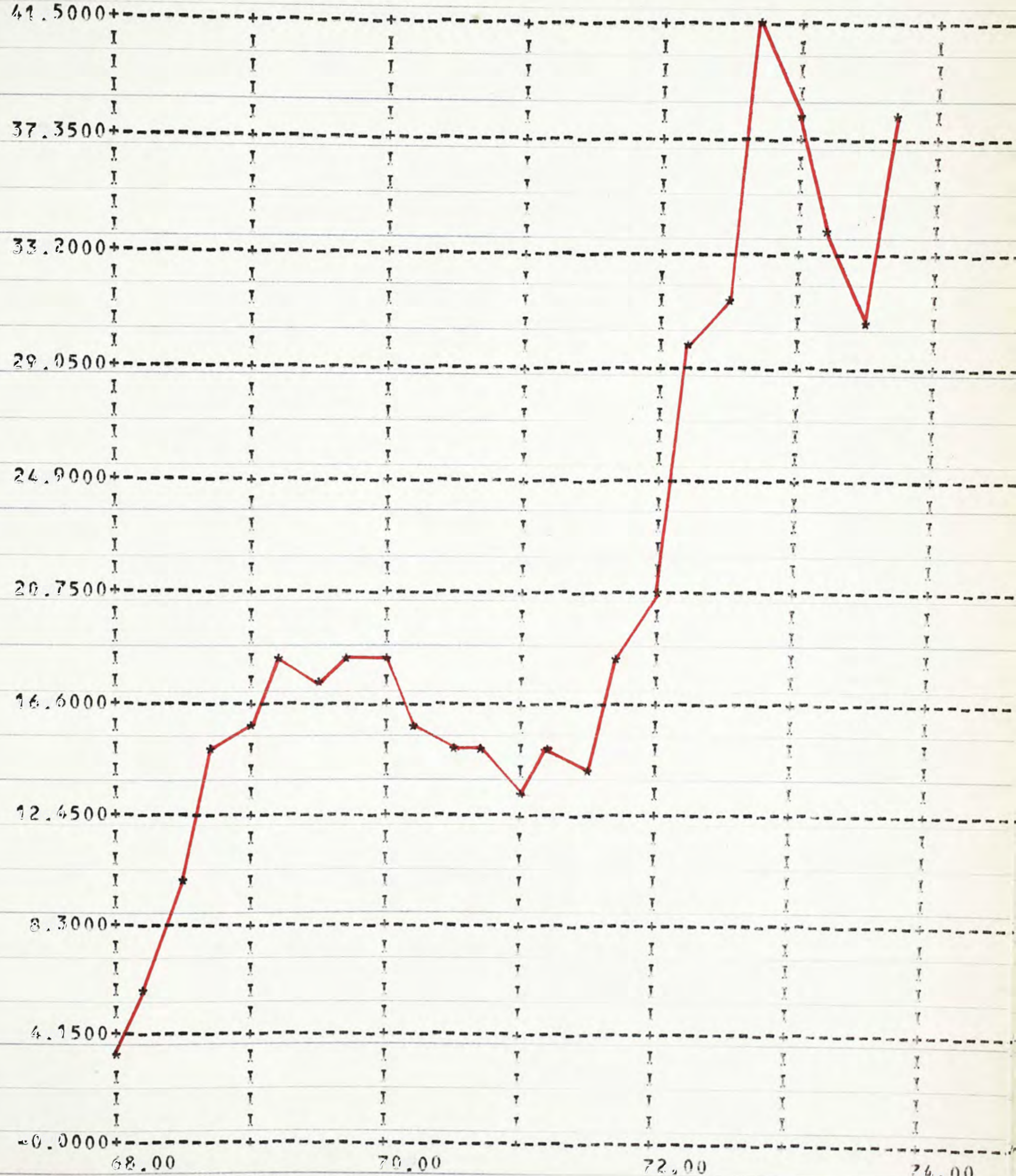
WHEELOCK MARDEN AND COMPANY LIMITED

FIGURE 19



A. S. WATSON AND COMPANY LIMITED

FIGURE 20

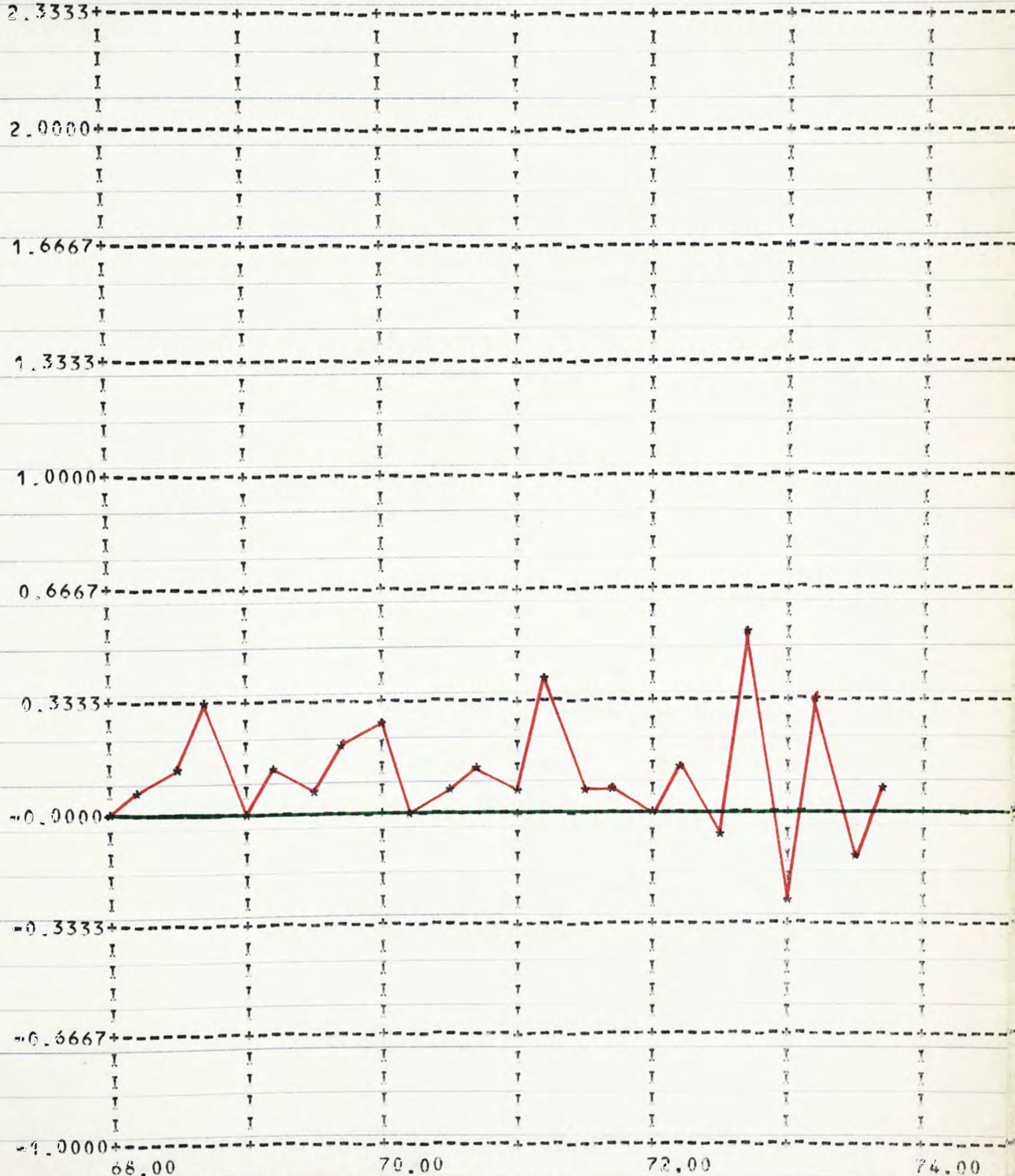


TEXTILE ALLIANCE LIMITED

APPENDIX J

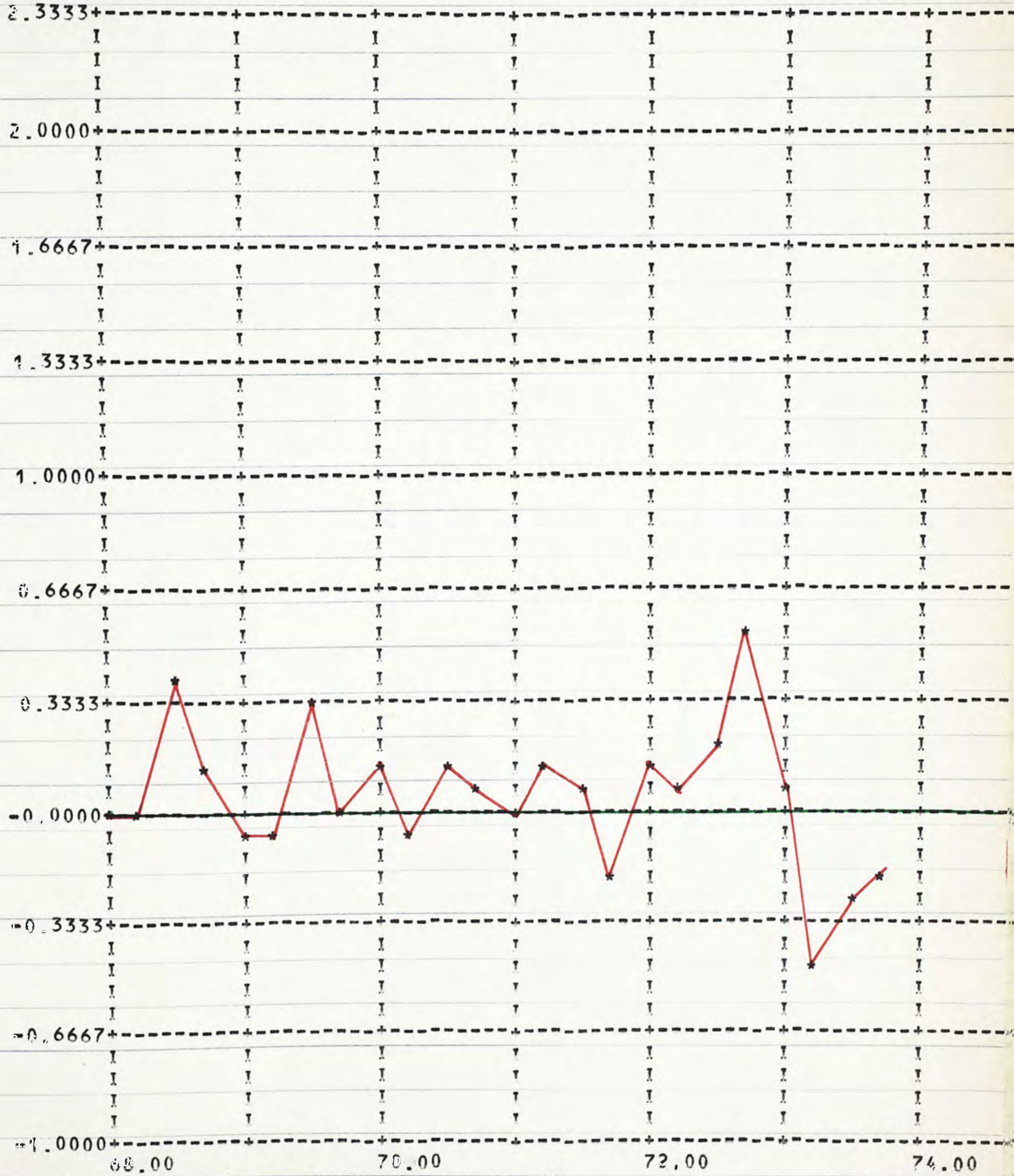
PLOT OF RATE OF RETURN ON INVESTMENT AGAINST TIME

FIGURE 1



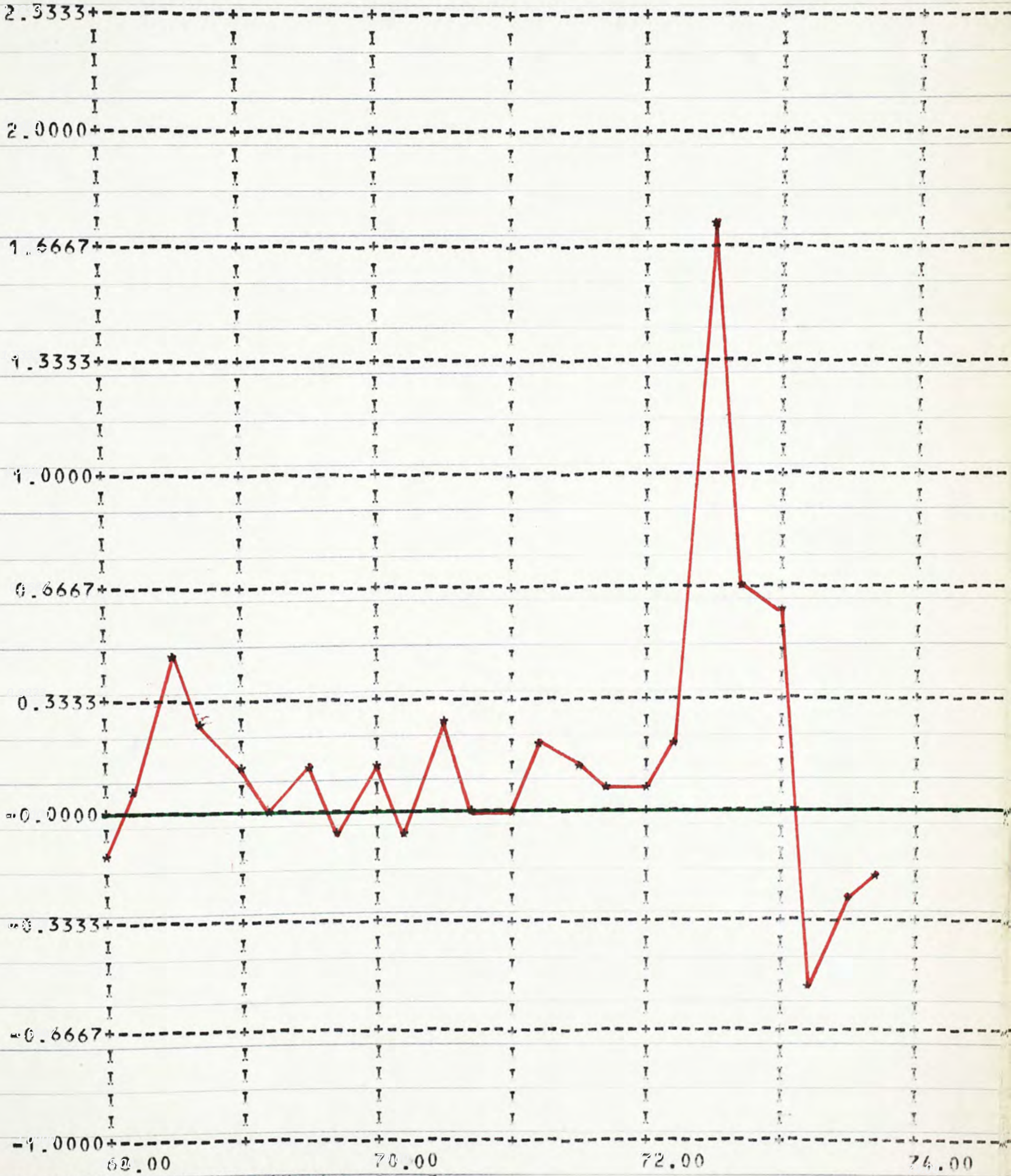
THE HONGKONG AND SHANGHAI BANKING CORPORATION

FIGURE 2



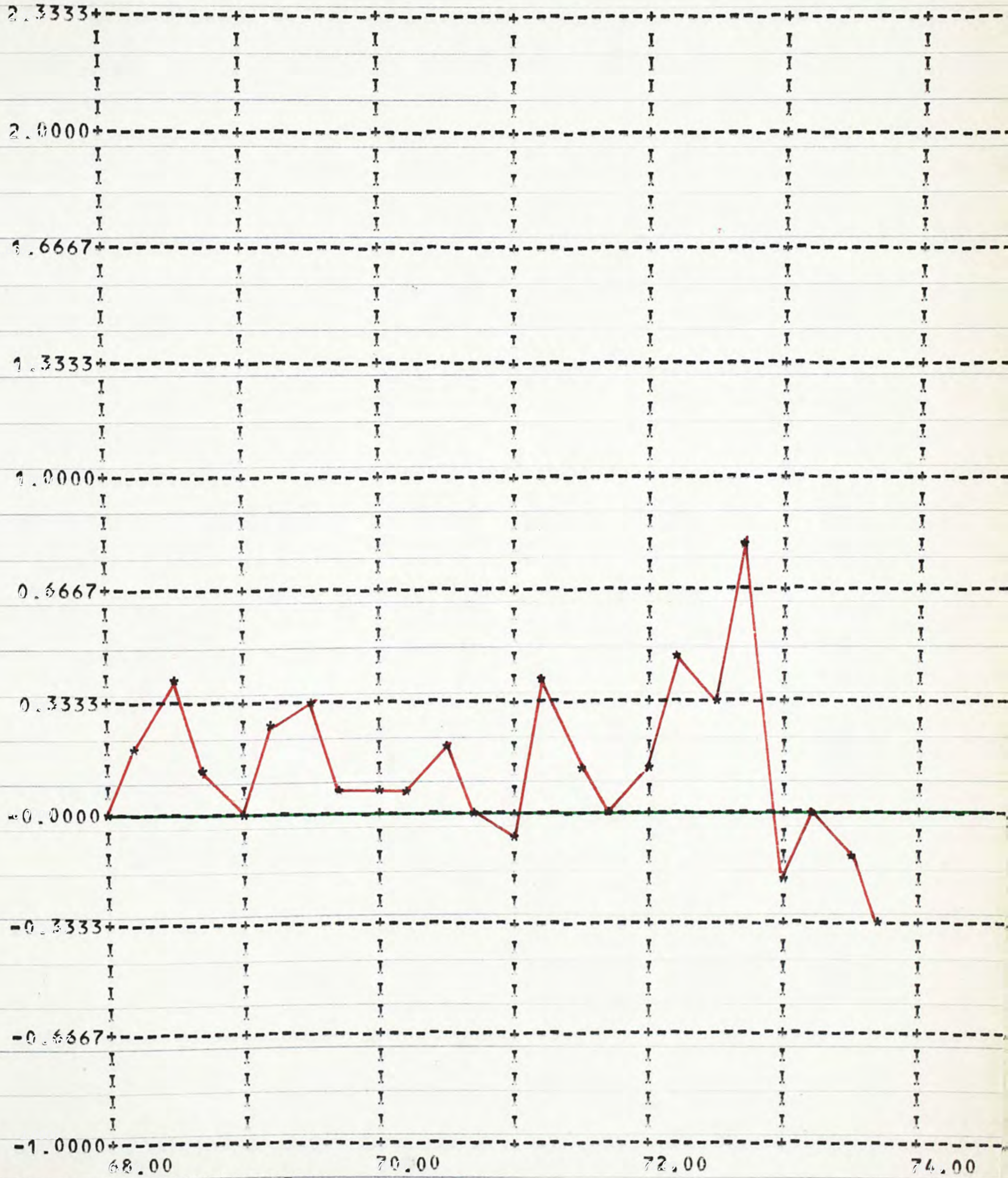
THE HONGKONG AND YAUMATI FERRY COMPANY LIMITED

FIGURE 3



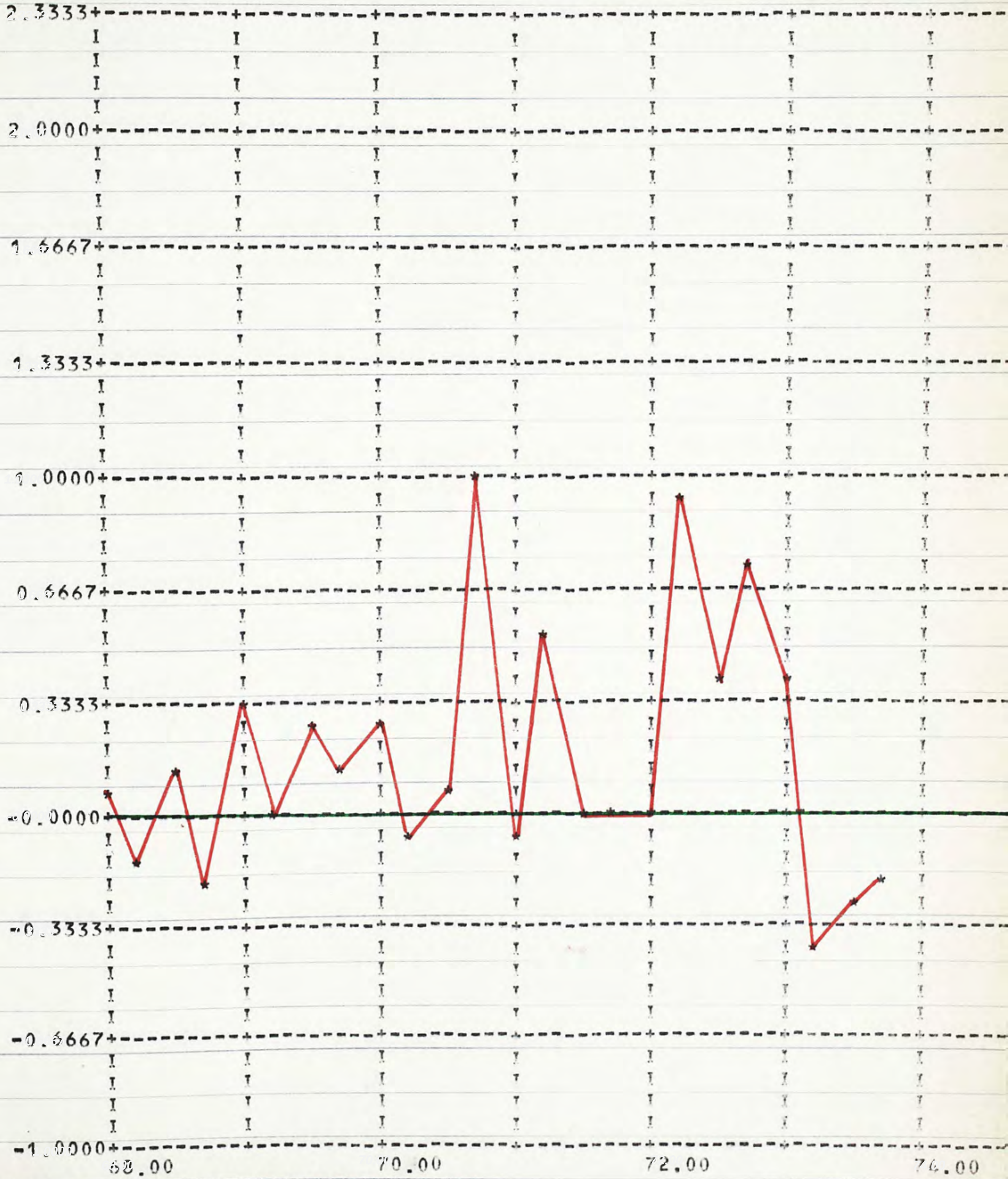
THE KOWLOON MOTOR BUS COMPANY LIMITED

FIGURE 4



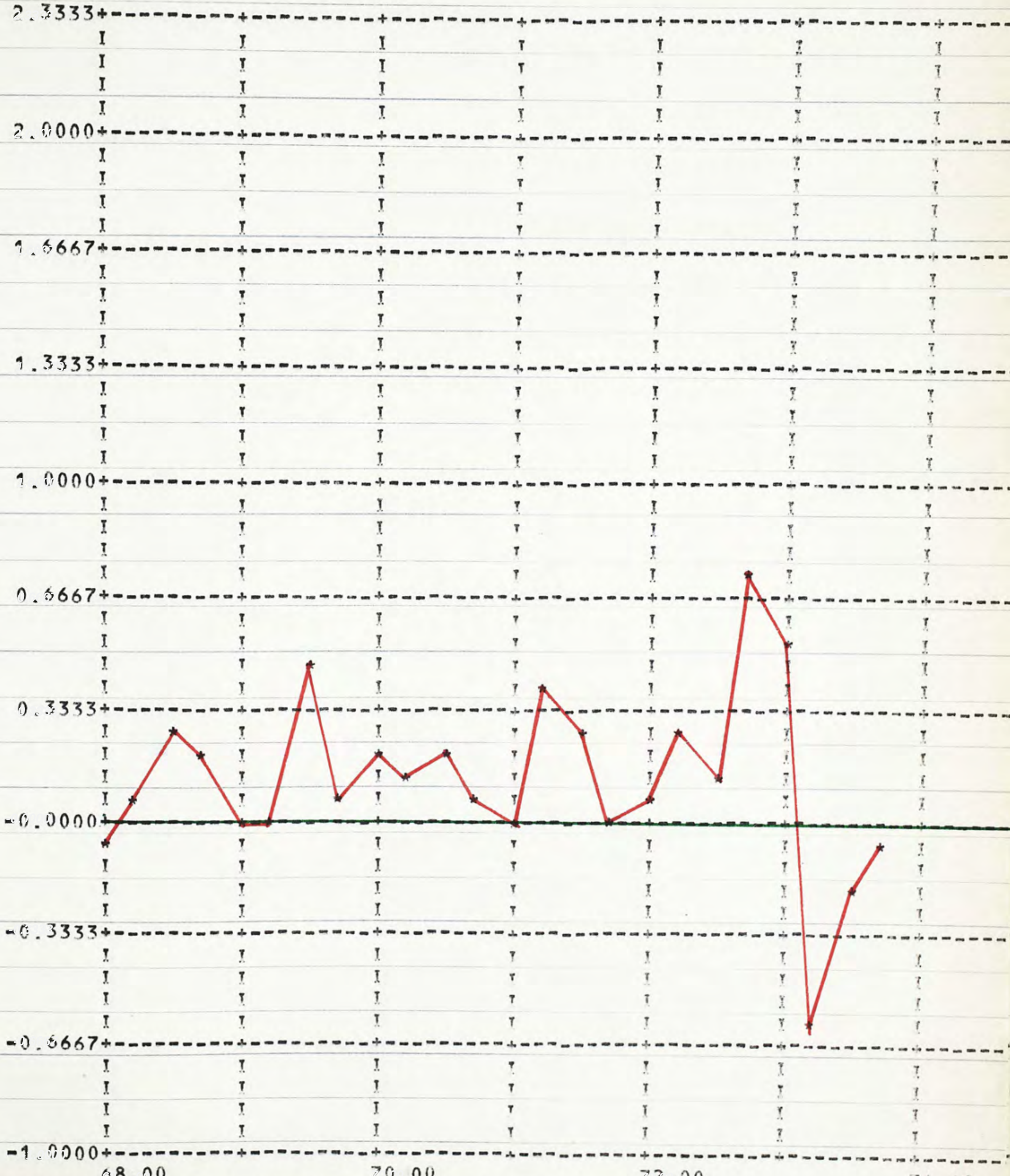
JARDINE SECURITIES LIMITED

FIGURE 5



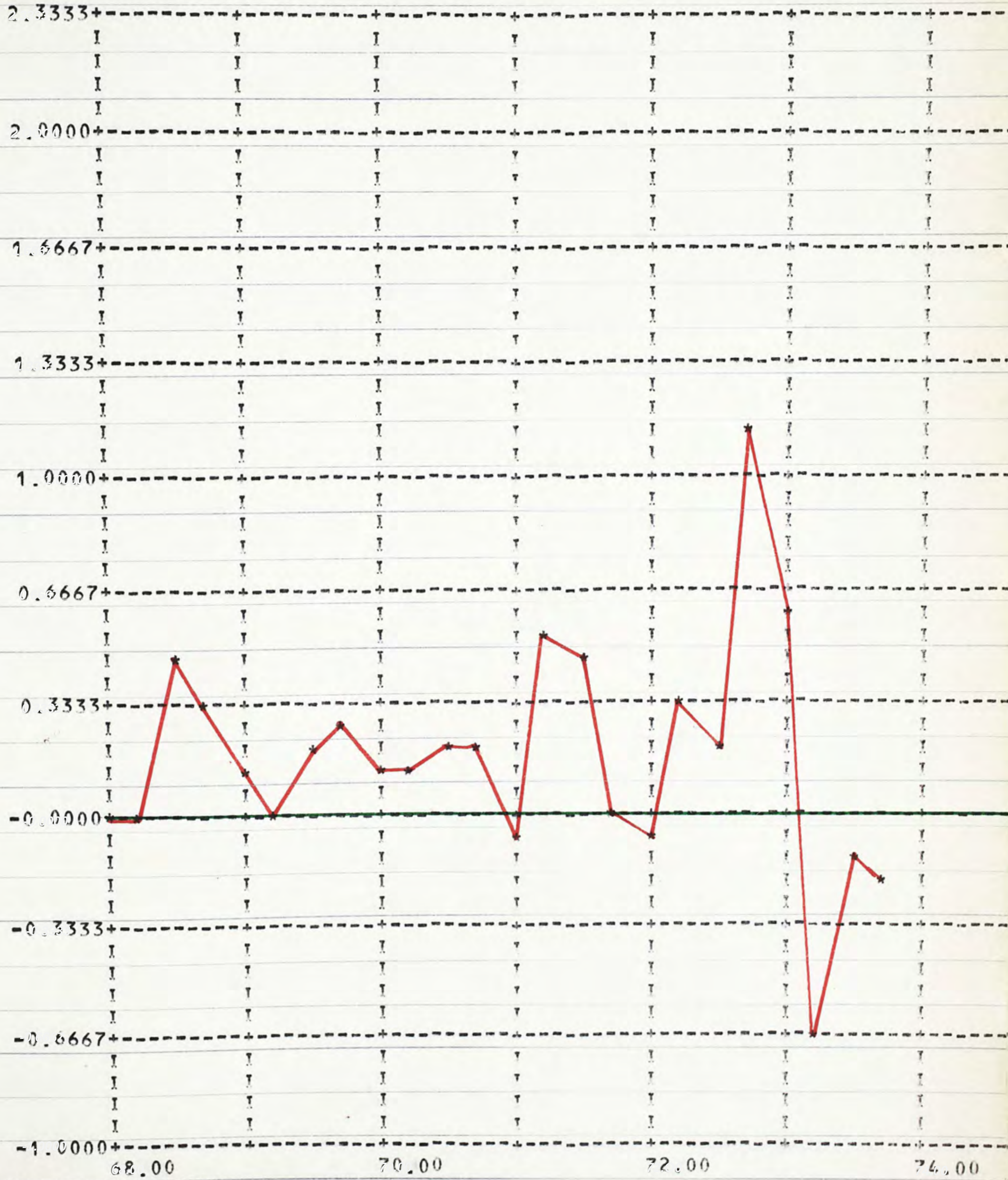
EASTERN ASIA NAVIGATION COMPANY LIMITED

FIGURE 6



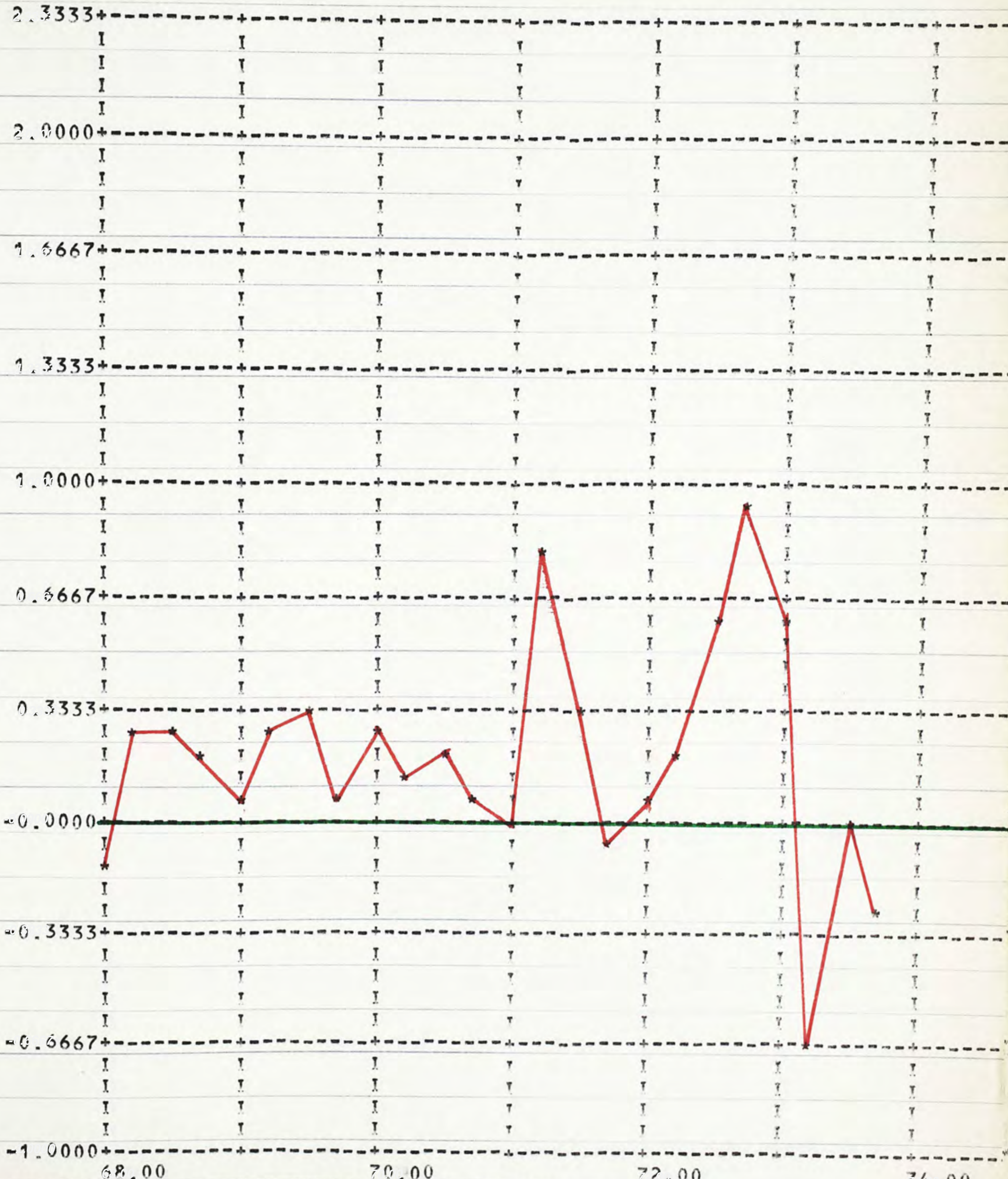
HONGKONG AND WHAMPOA DOCK COMPANY LIMITED

FIGURE 7



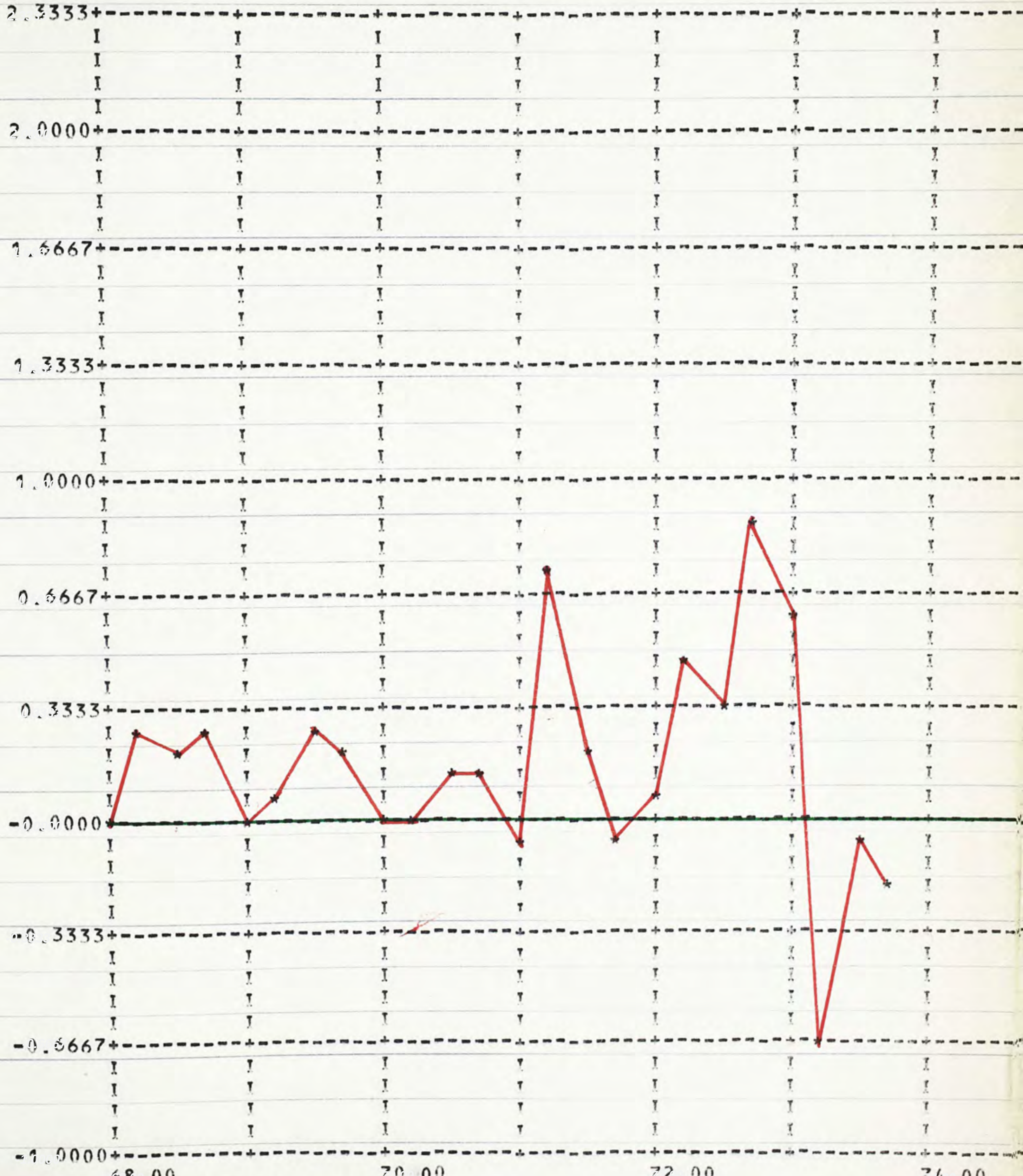
TAIKOO SWIRE LIMITED

FIGURE 8



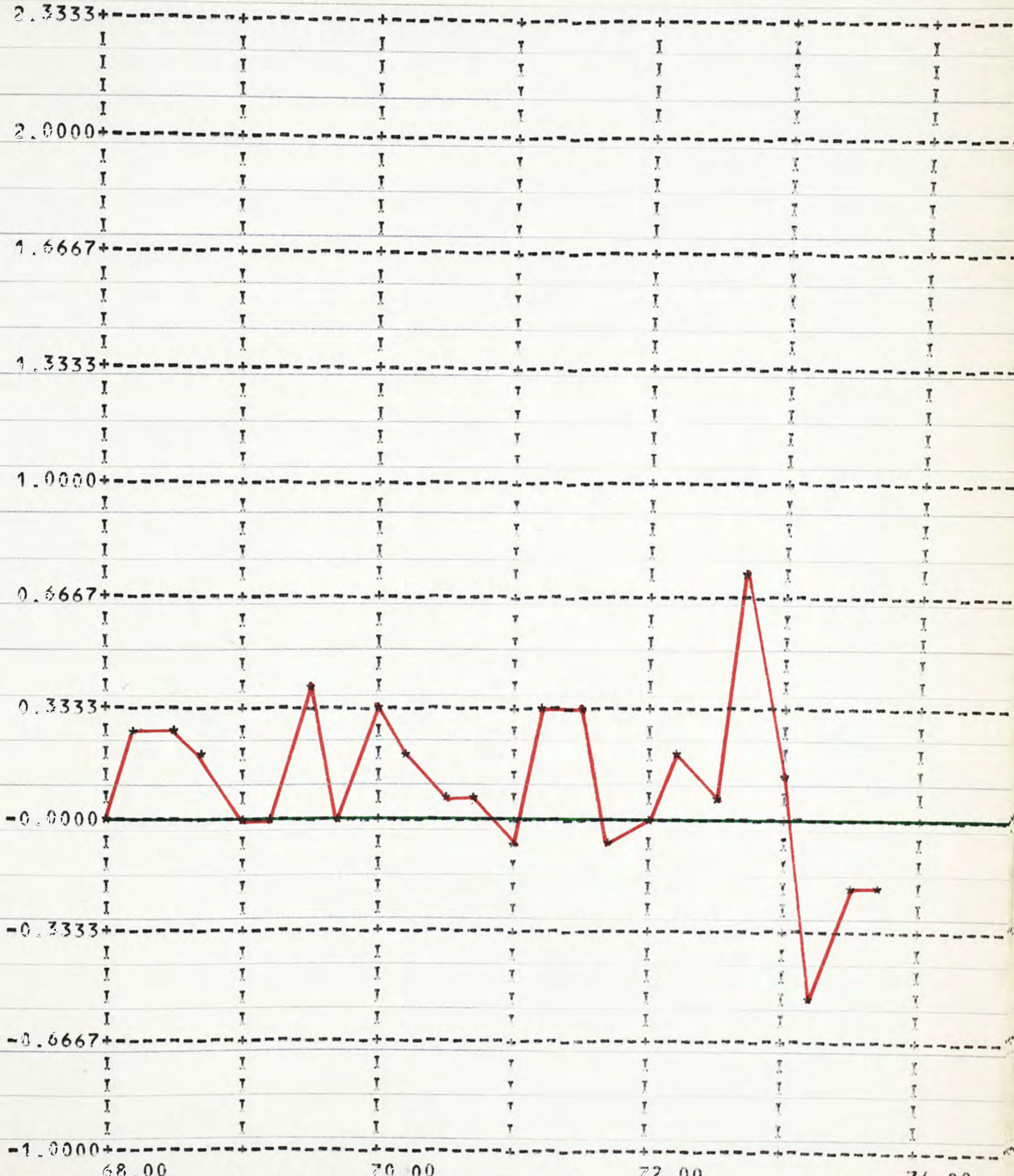
THE HONGKONG AND KOWLOON WHARF AND GODOWN COMPANY LIMITED

FIGURE 9



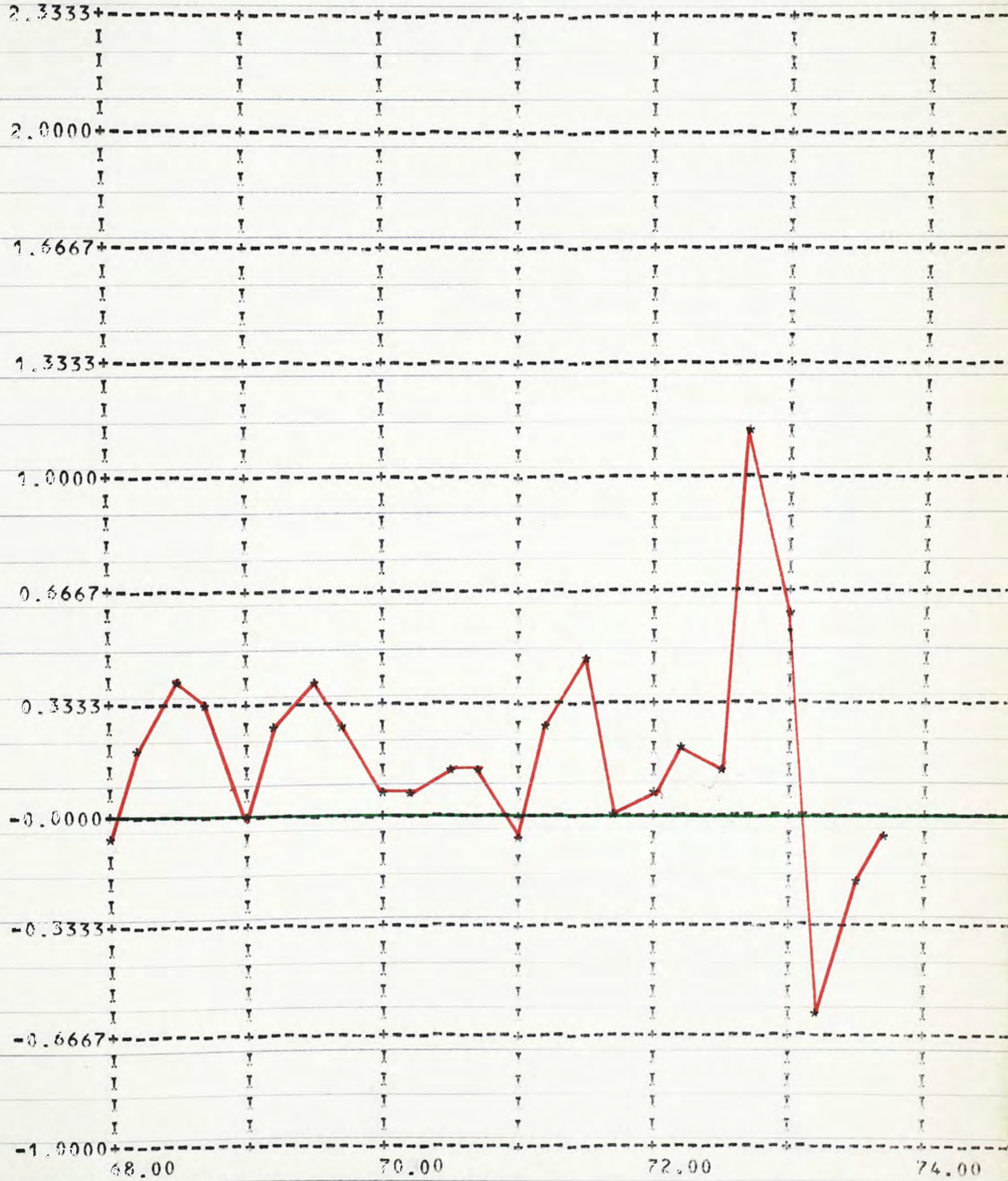
THE HONGKONG LAND COMPANY LIMITED

FIGURE 10



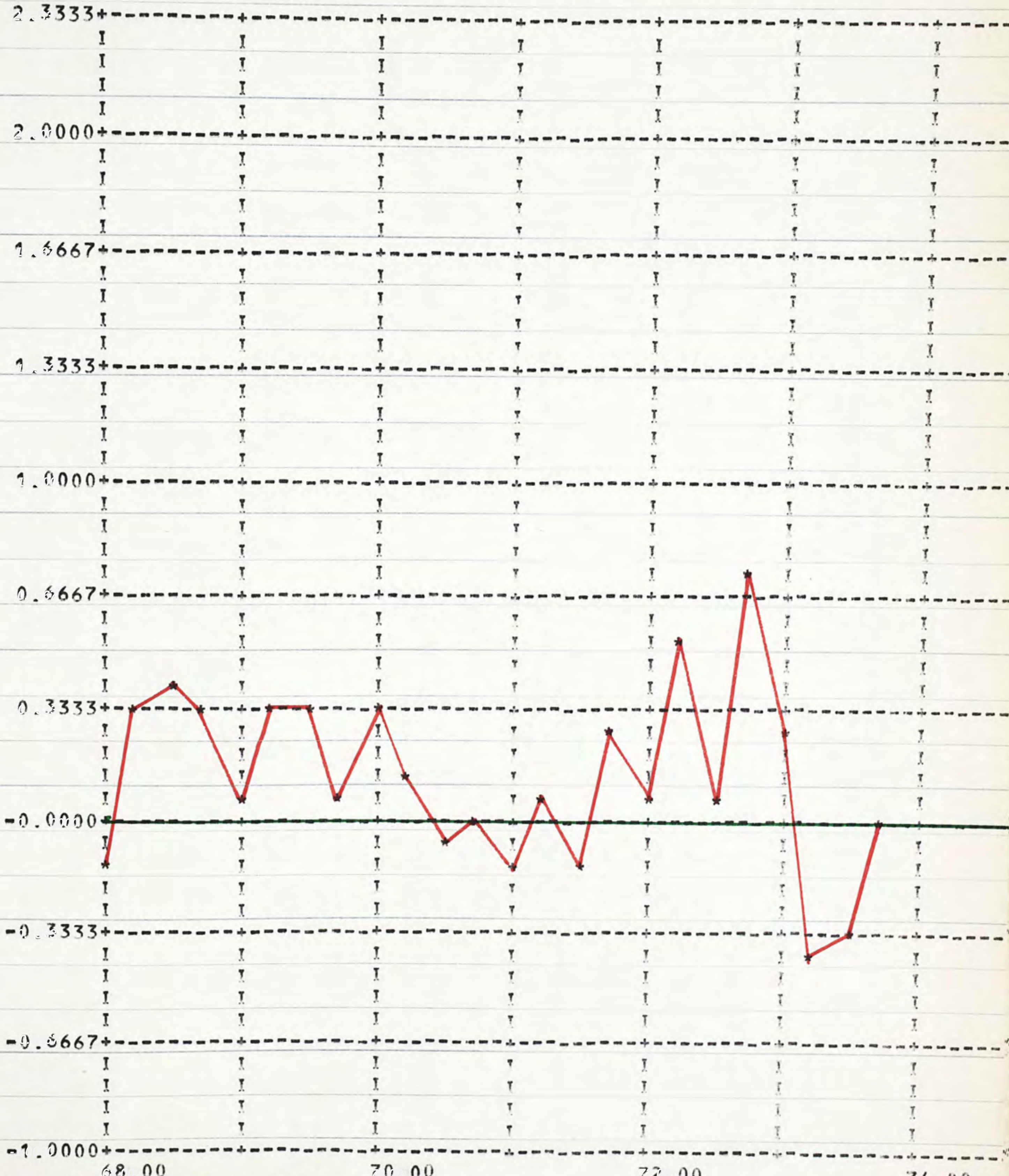
HONGKONG REALTY AND TRUST COMPANY LIMITED

FIGURE 11



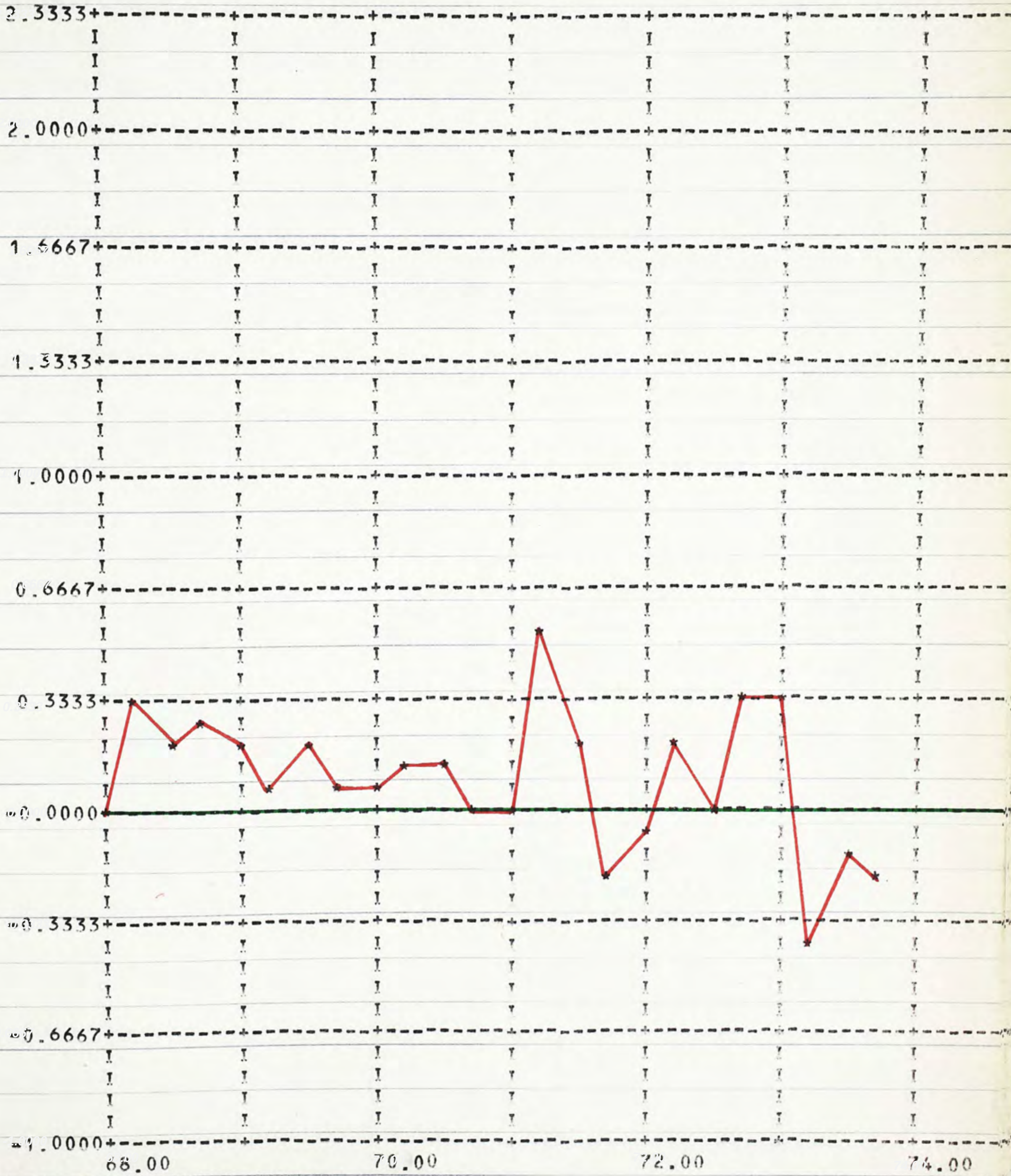
THE HONGKONG AND SHANGHAI HOTELS LIMITED

FIGURE 12



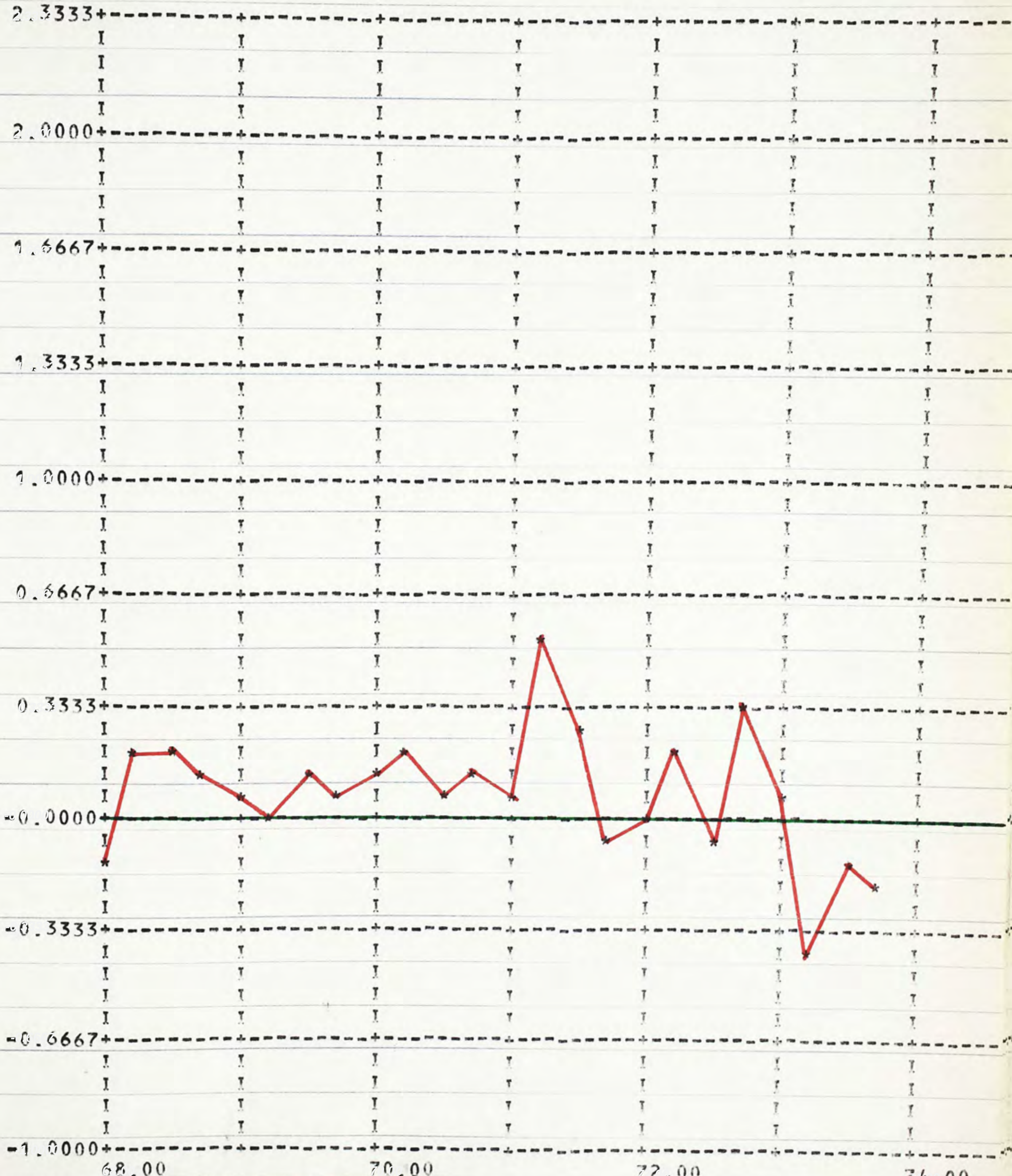
CITY HOTELS LIMITED

FIGURE 13



CHINA LIGHT AND POWER COMPANY LIMITED

FIGURE 14

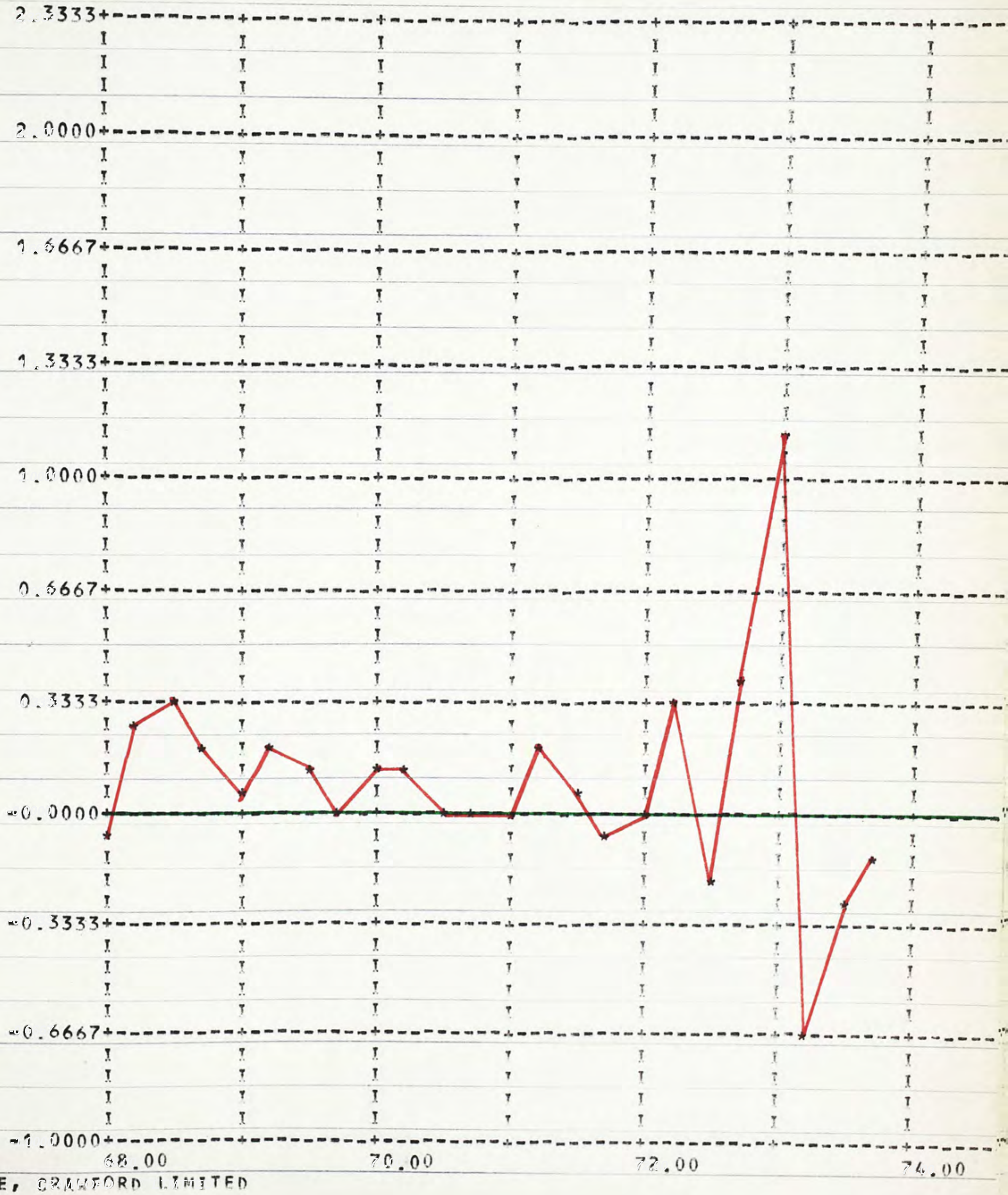


HONG KONG TELEPHONE COMPANY LIMITED

FIGURE 15

THE HONG KONG AND CHINA GAS COMPANY LIMITED

FIGURE 16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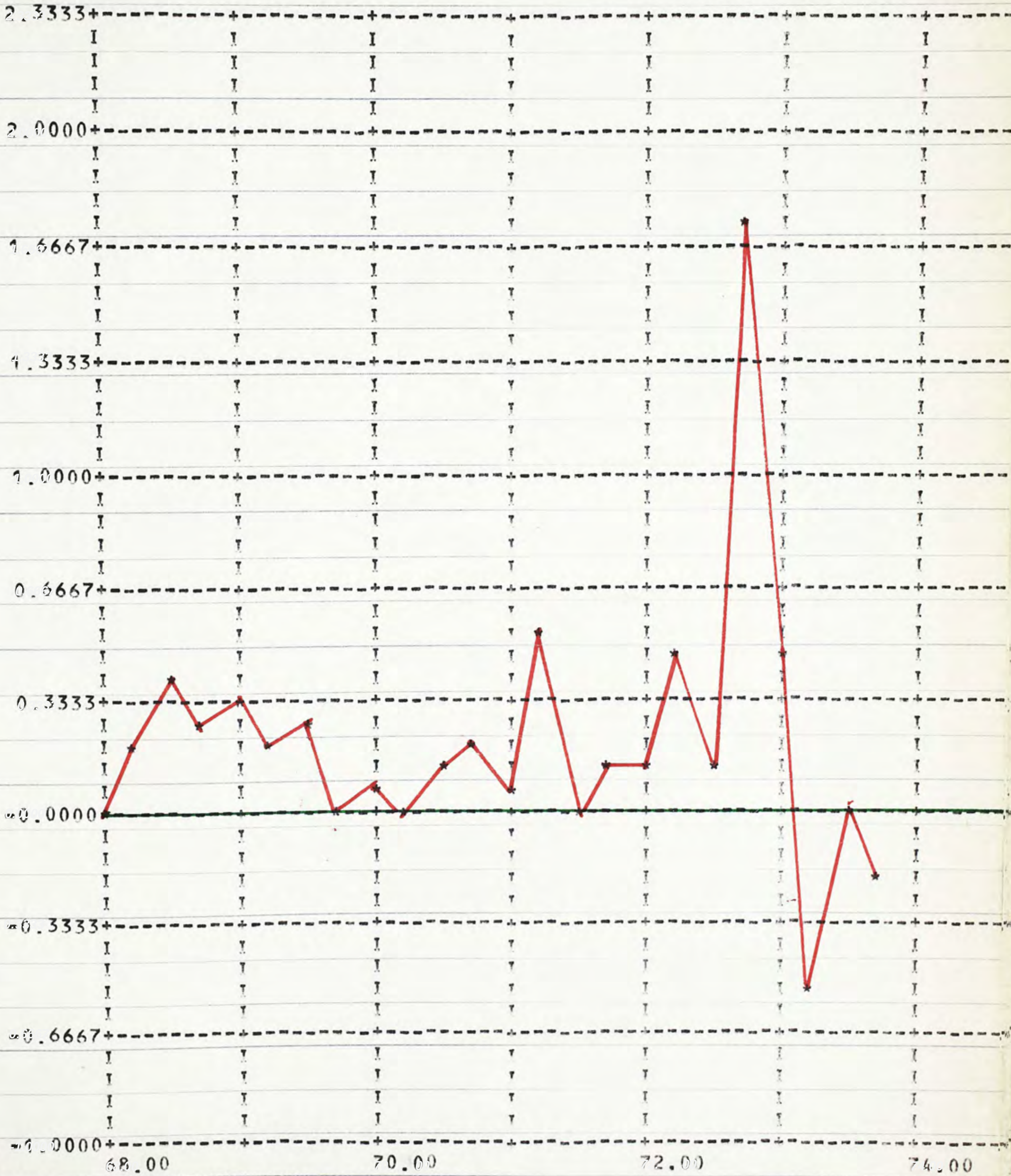
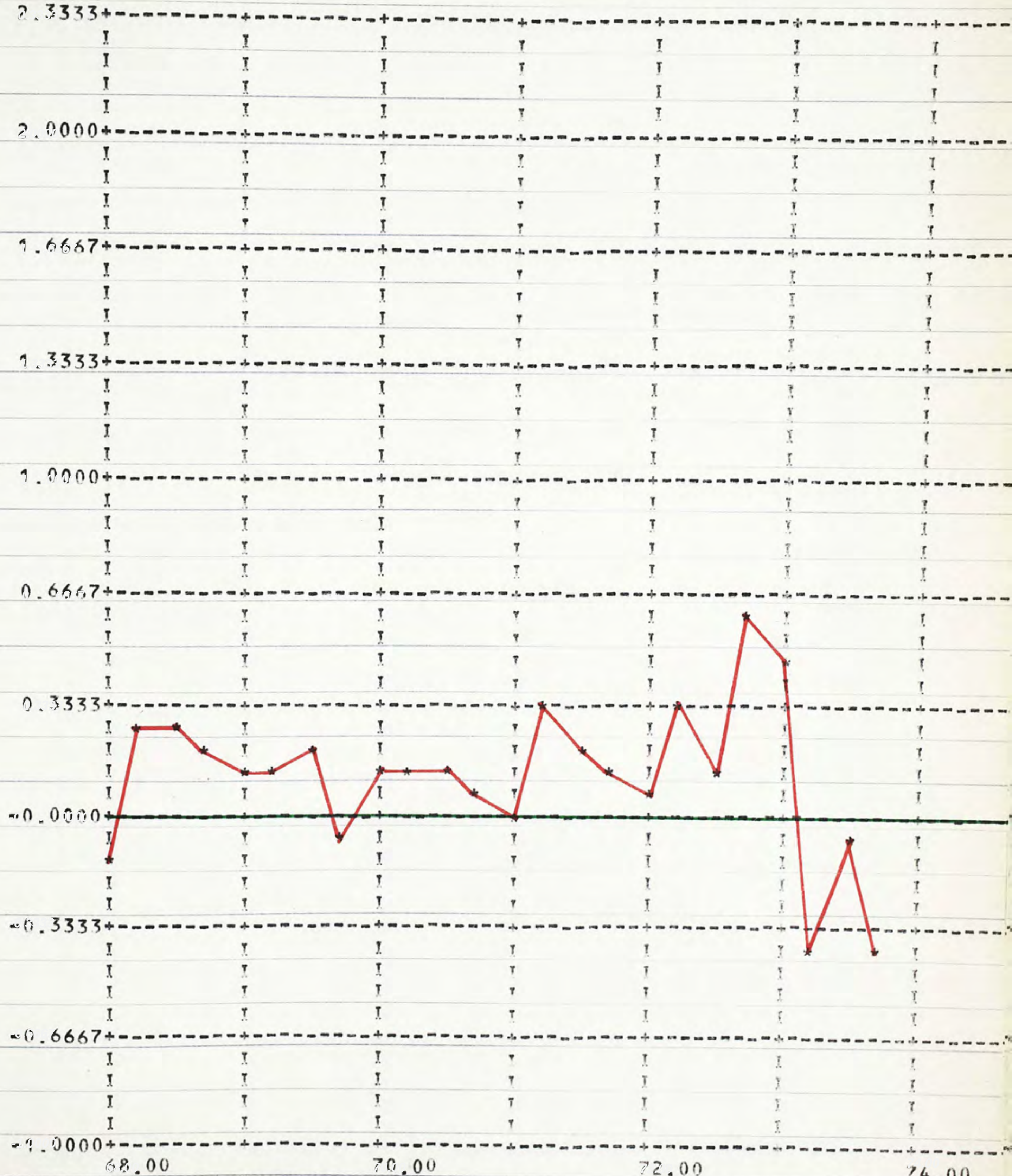
70.00
72.00
74.00
LAKE, CRAWFORD LIMITED

FIGURE 17



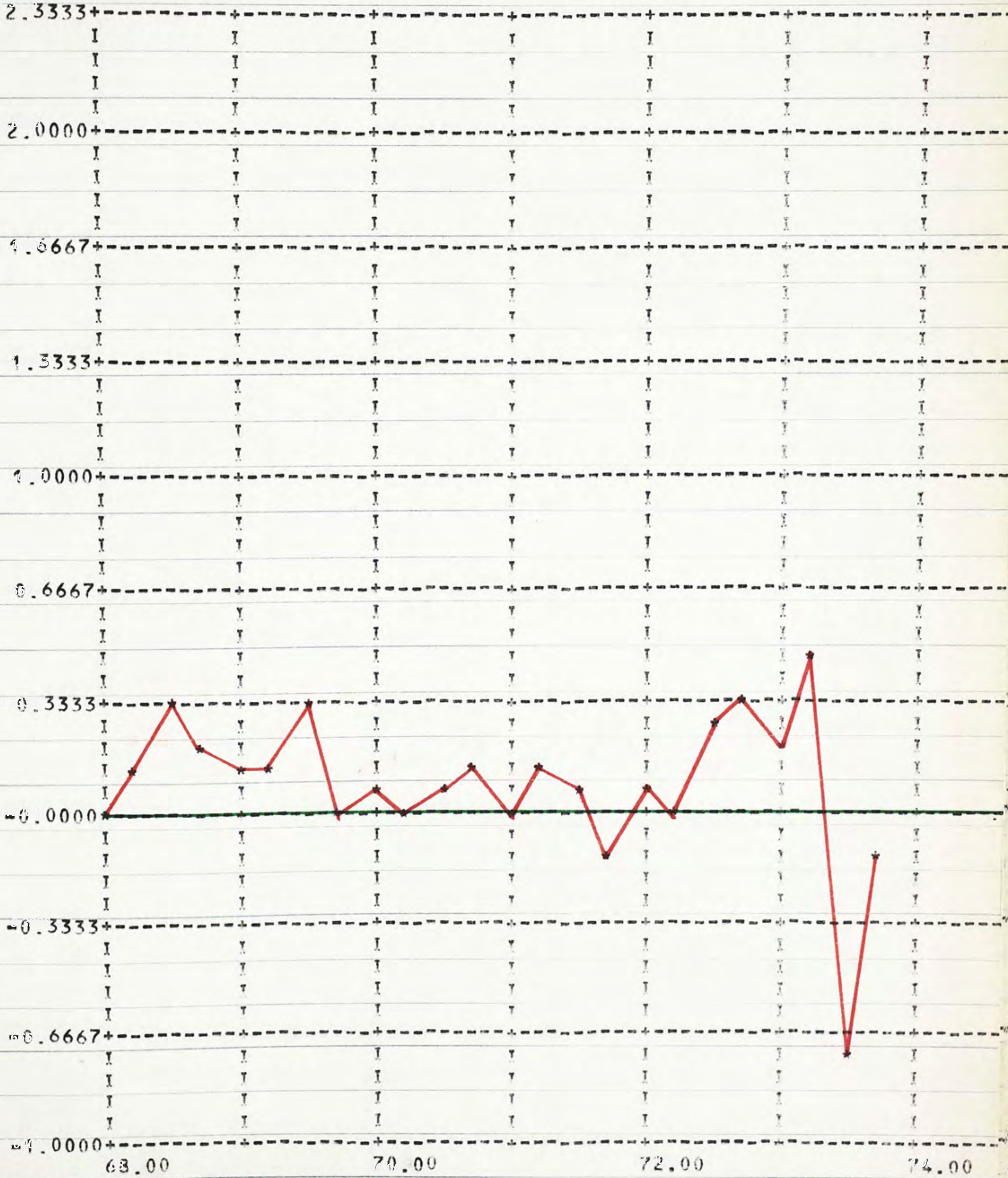
JARDINE, MATHESON AND COMPANY LIMITED

FIGURE 18



WHEELOCK MARDEN AND COMPANY LIMITED

FIGURE 19



A. S. WATSON AND COMPANY LIMITED

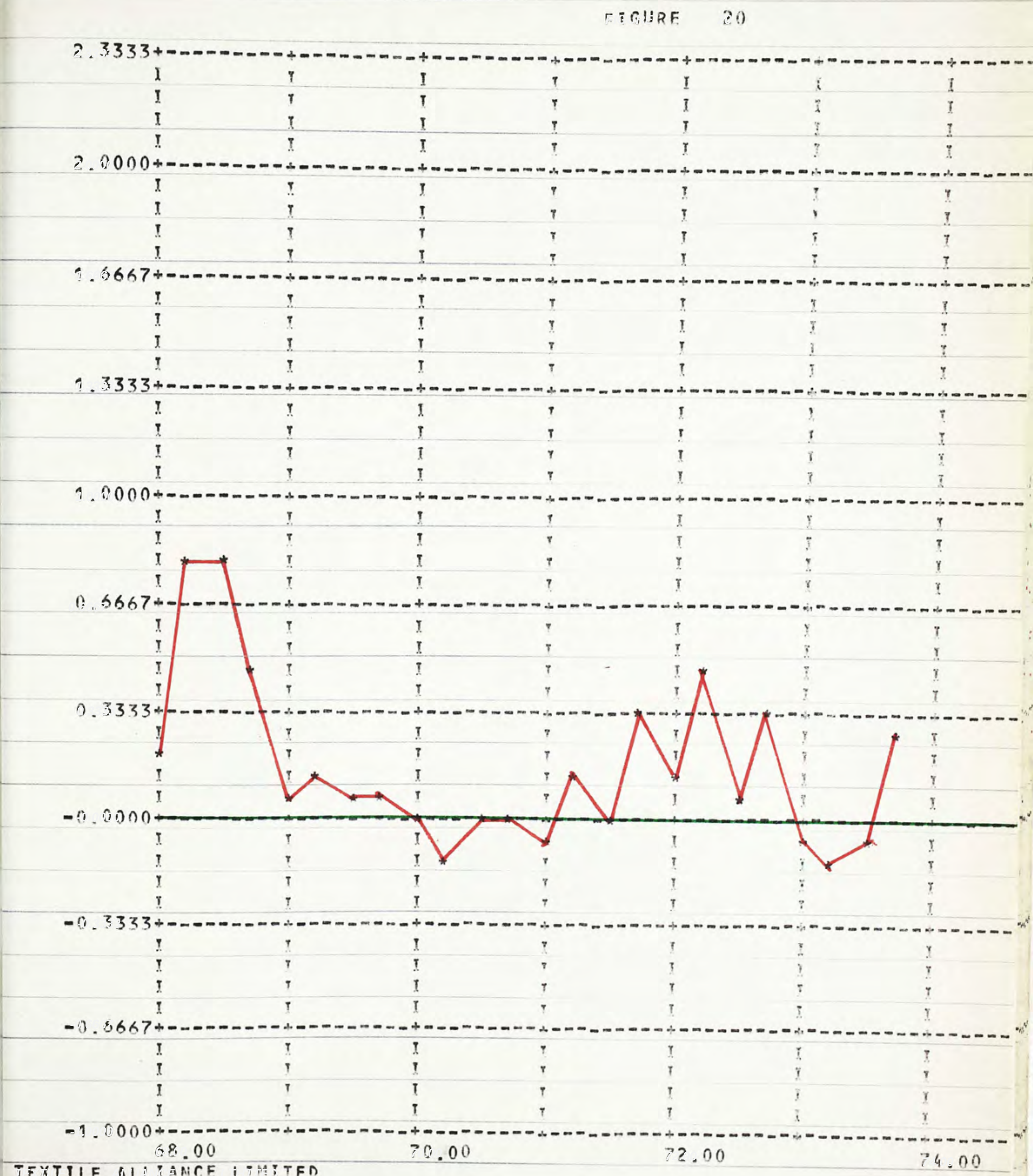


FIGURE 20
2.3333
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-1.0000
68.00
70.00
72.00
74.00
TEXTILE ALLIANCE LIMITED

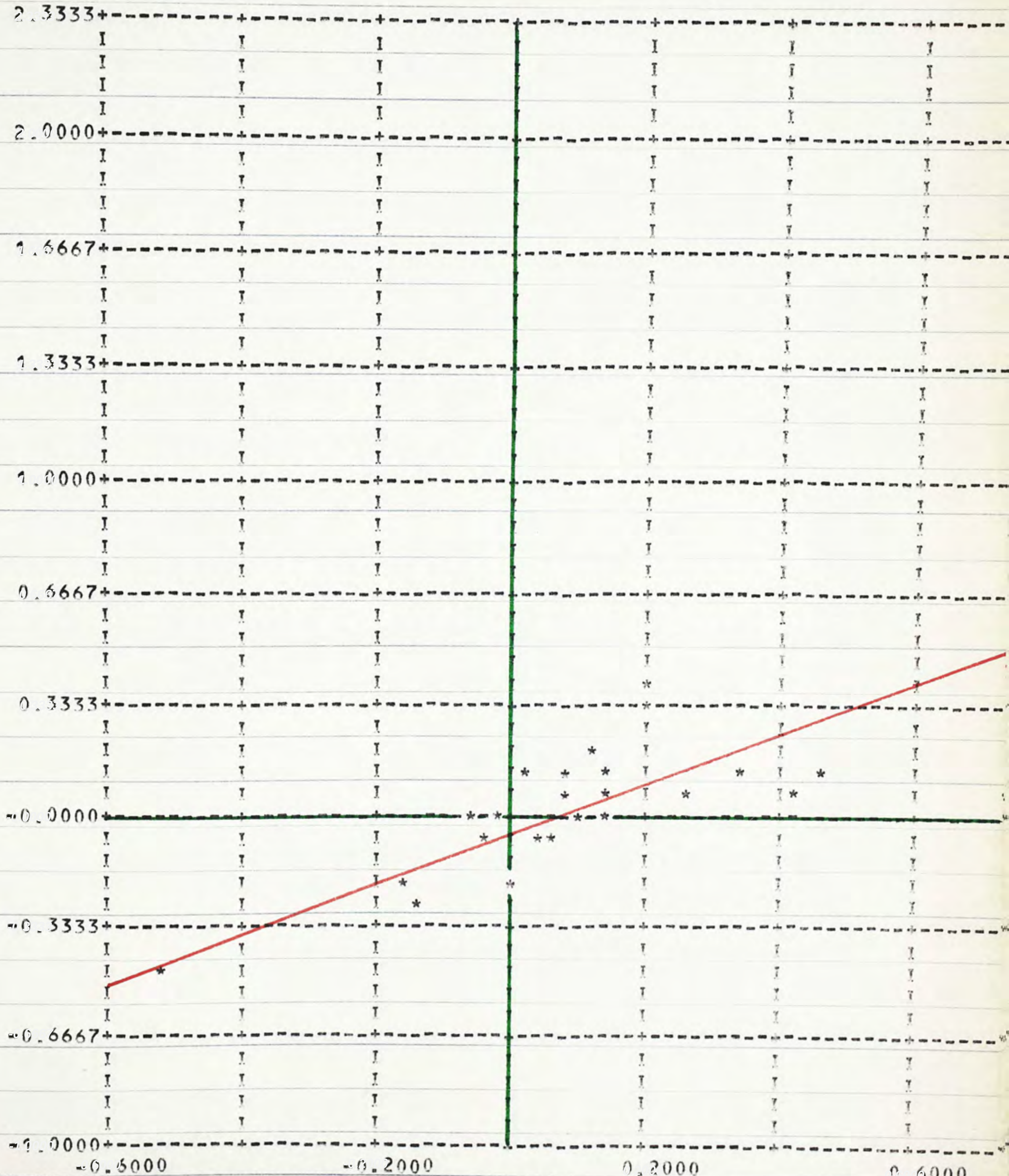
APPENDIX K

PLOT OF RATE OF RETURN AGAINST RATE OF CHANGE OF MARKET INDEX

FIGURE 1

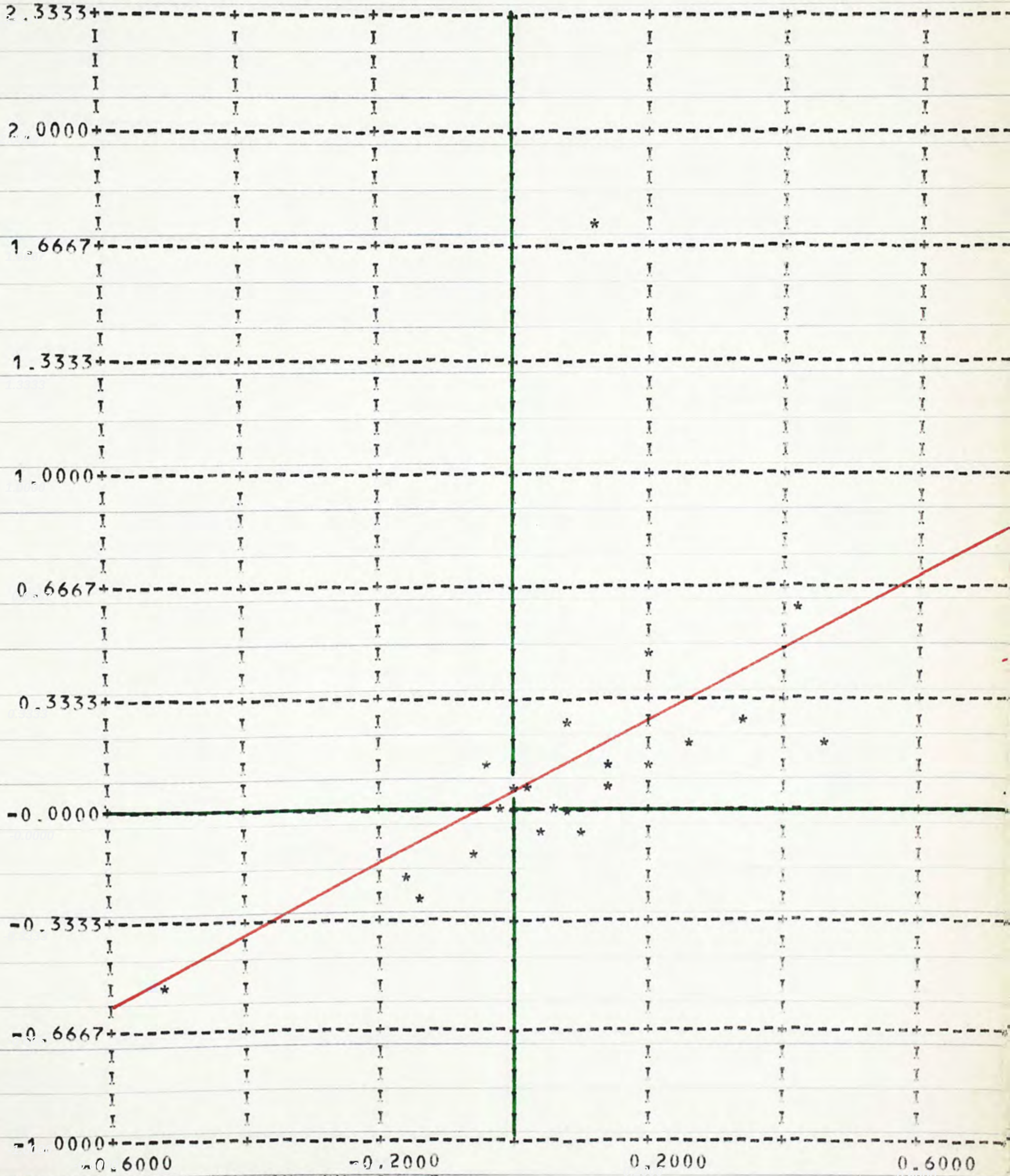
THE HONGKONG AND SHANGHAI BANKING CORPORATION

FIGURE 2



THE HONGKONG AND YAUMATI FERRY COMPANY LIMITED

FIGURE 3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-0.3333
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-0.2000
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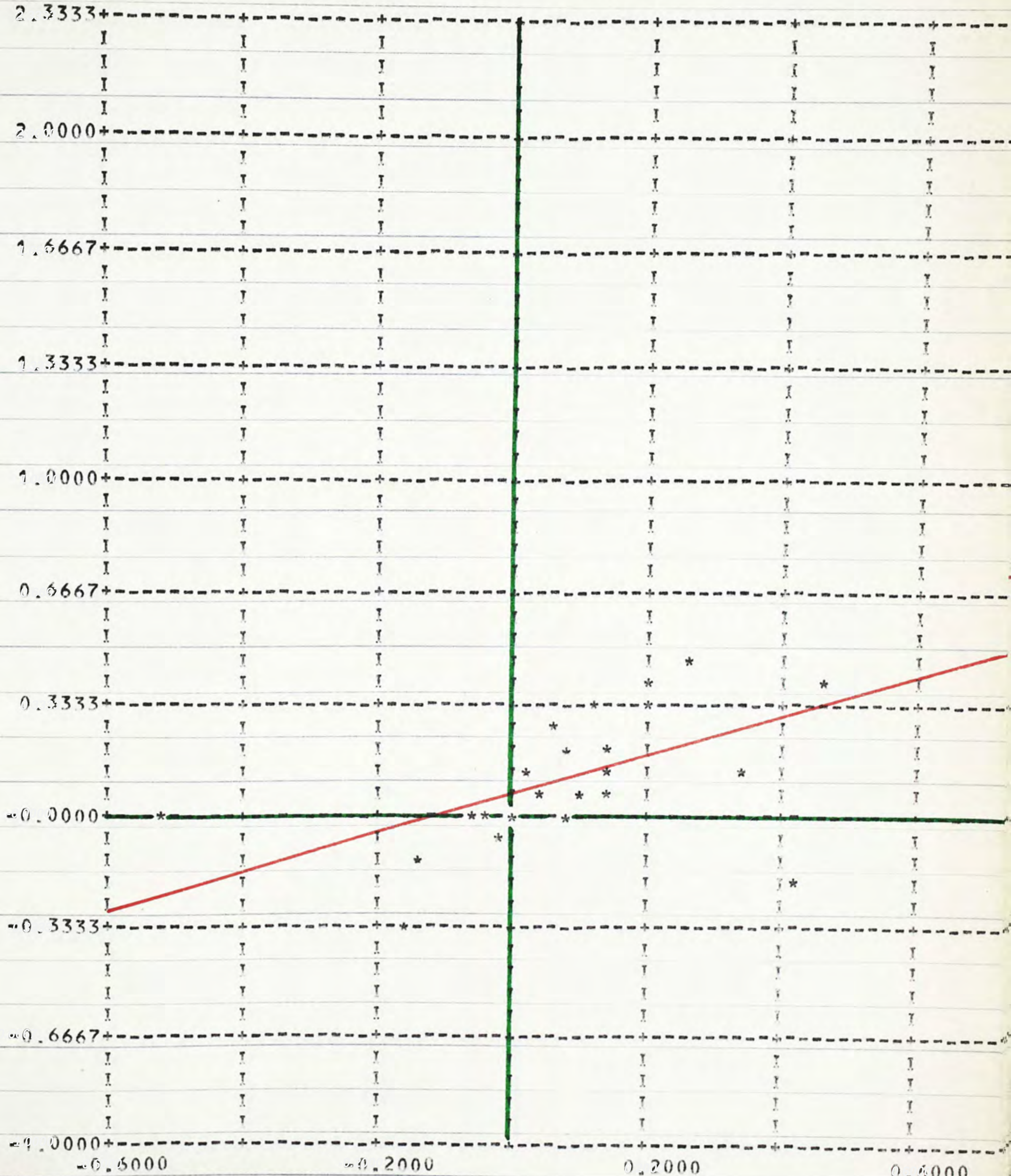
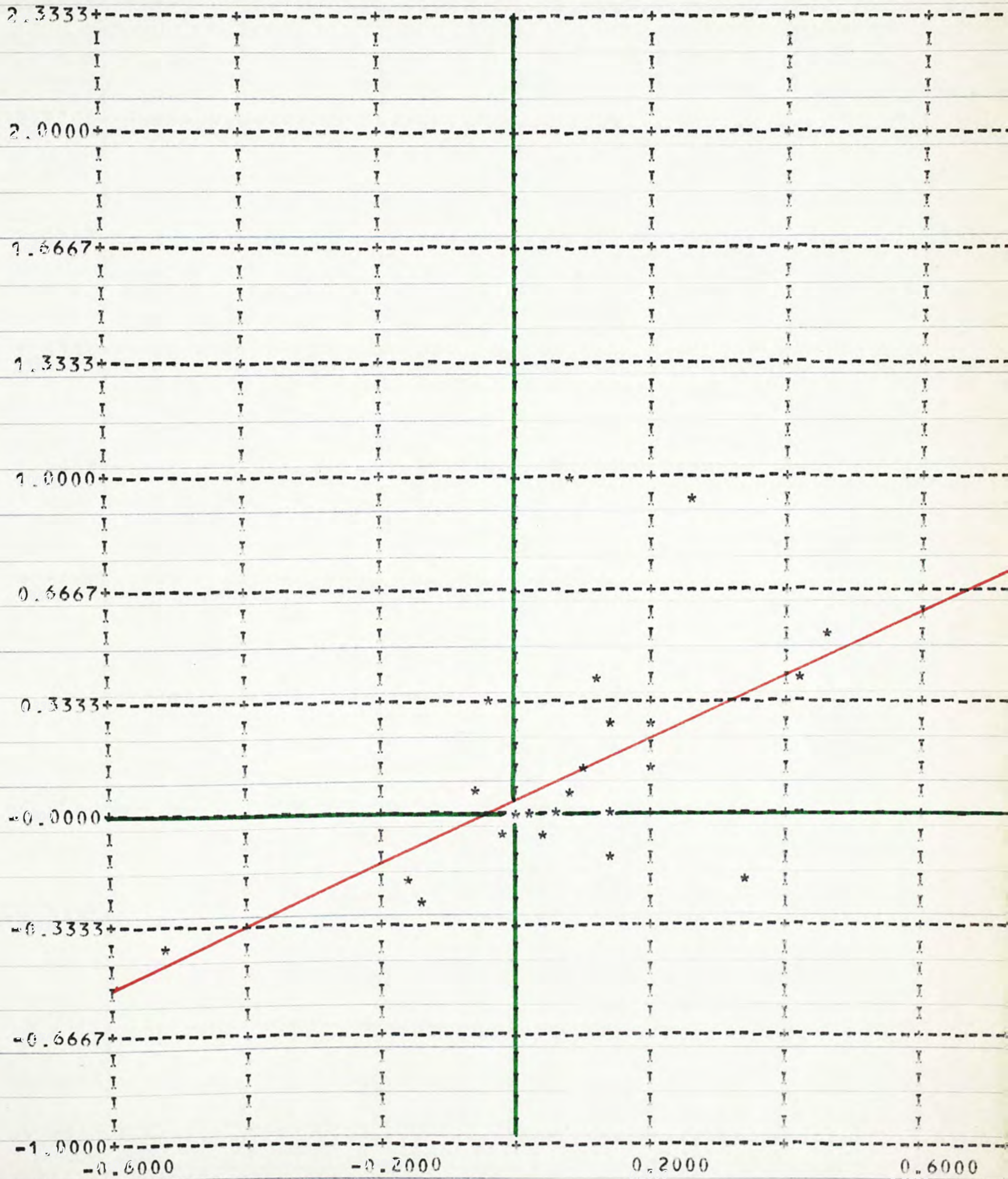
0.6000

FIGURE 4



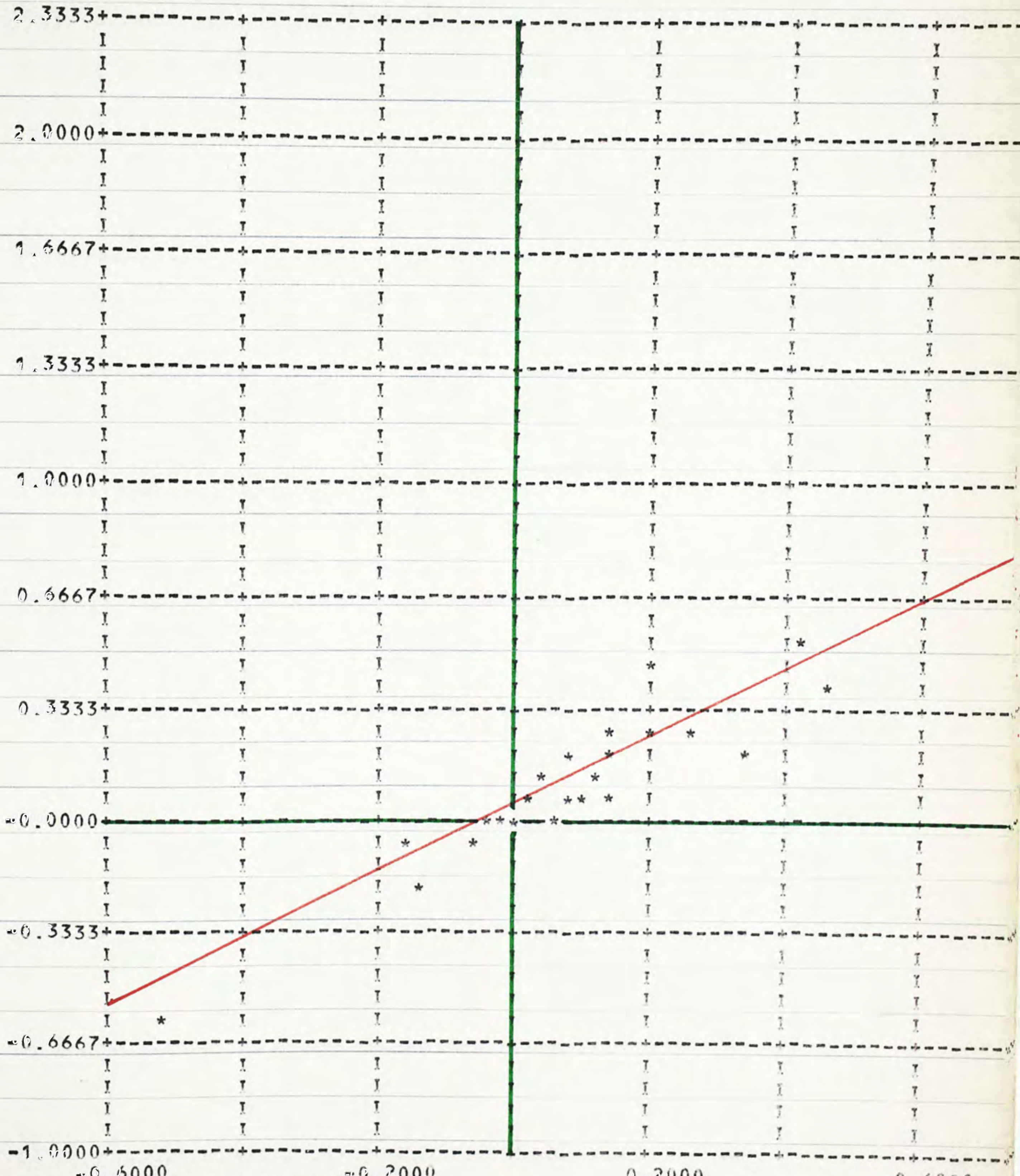
JARDINE SECURITIES LIMITED

FIGURE 5



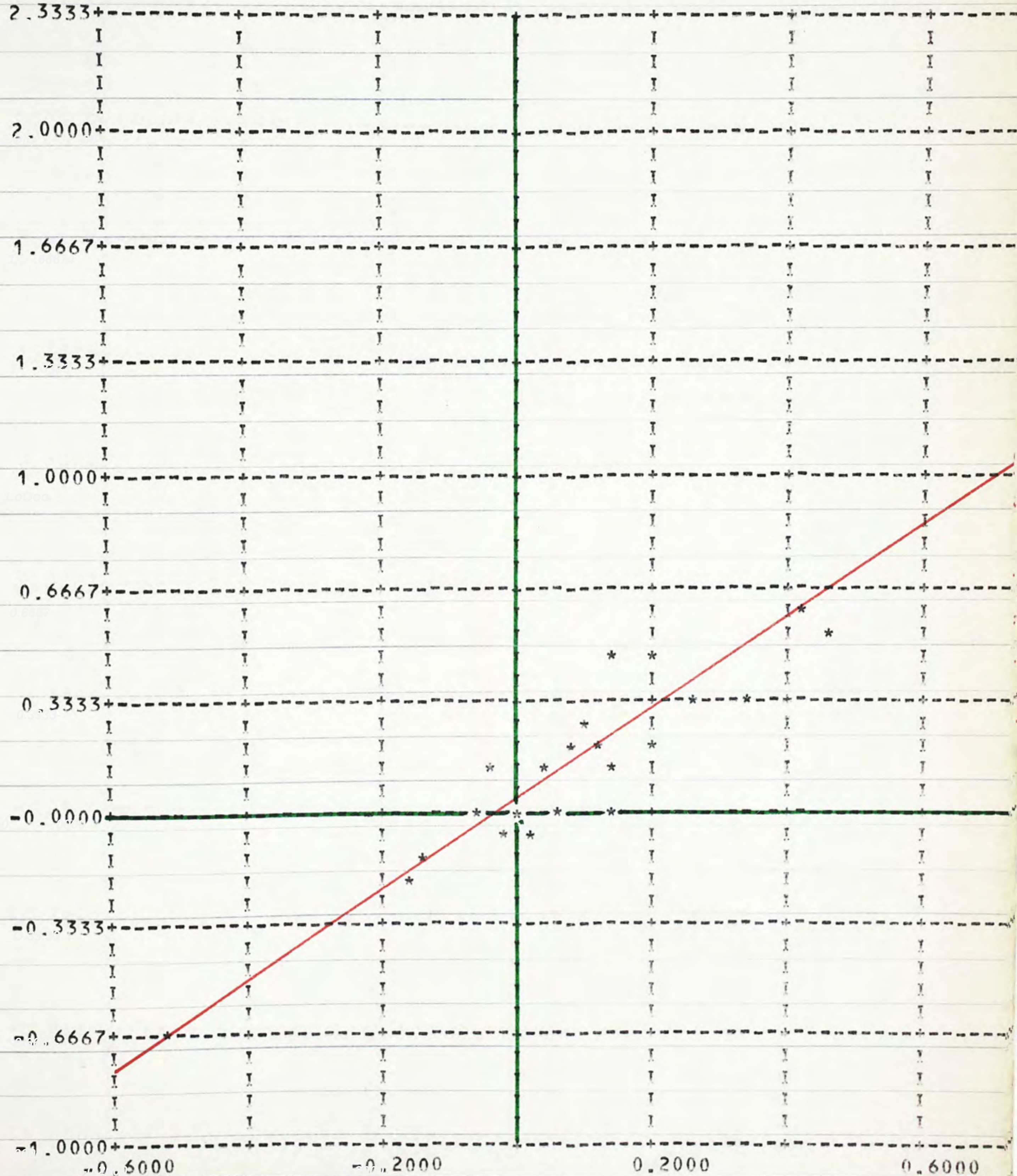
EASTERN ASIA NAVIGATION COMPANY LIMITED

FIGURE 6



HONGKONG AND WHAMPOA DOCK COMPANY LIMITED

FIGURE 7



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-0.2000
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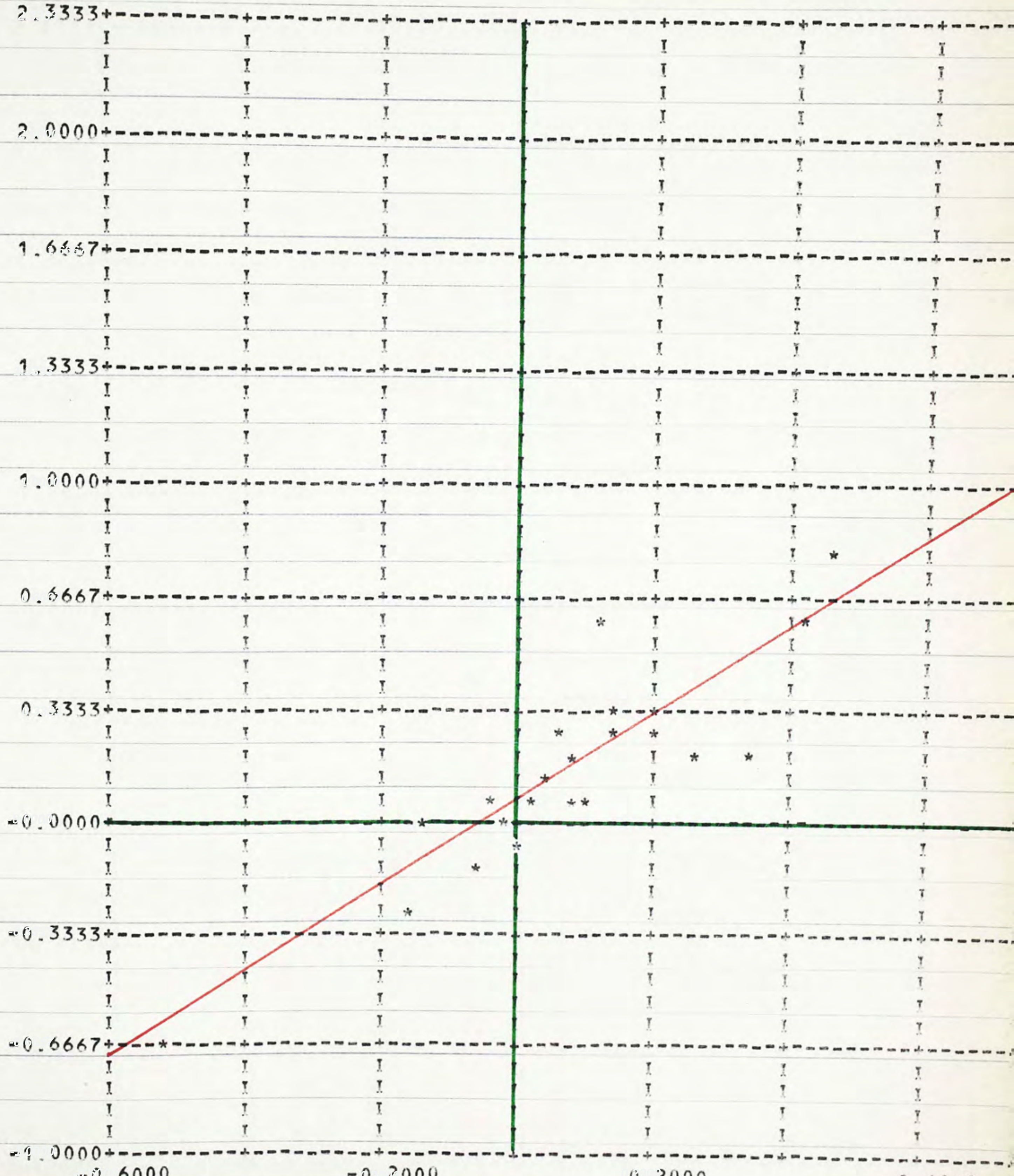
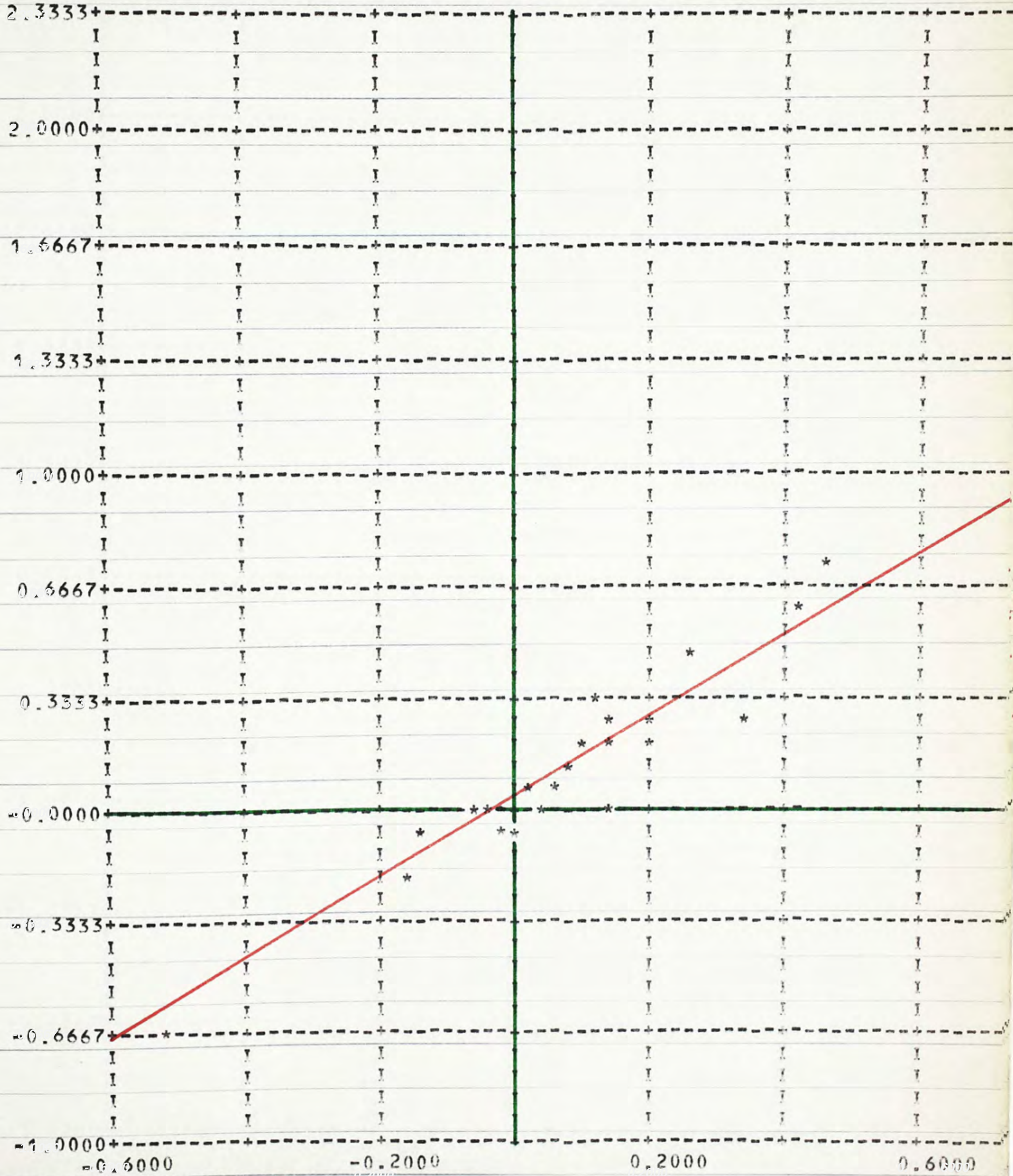
FIGURE 8



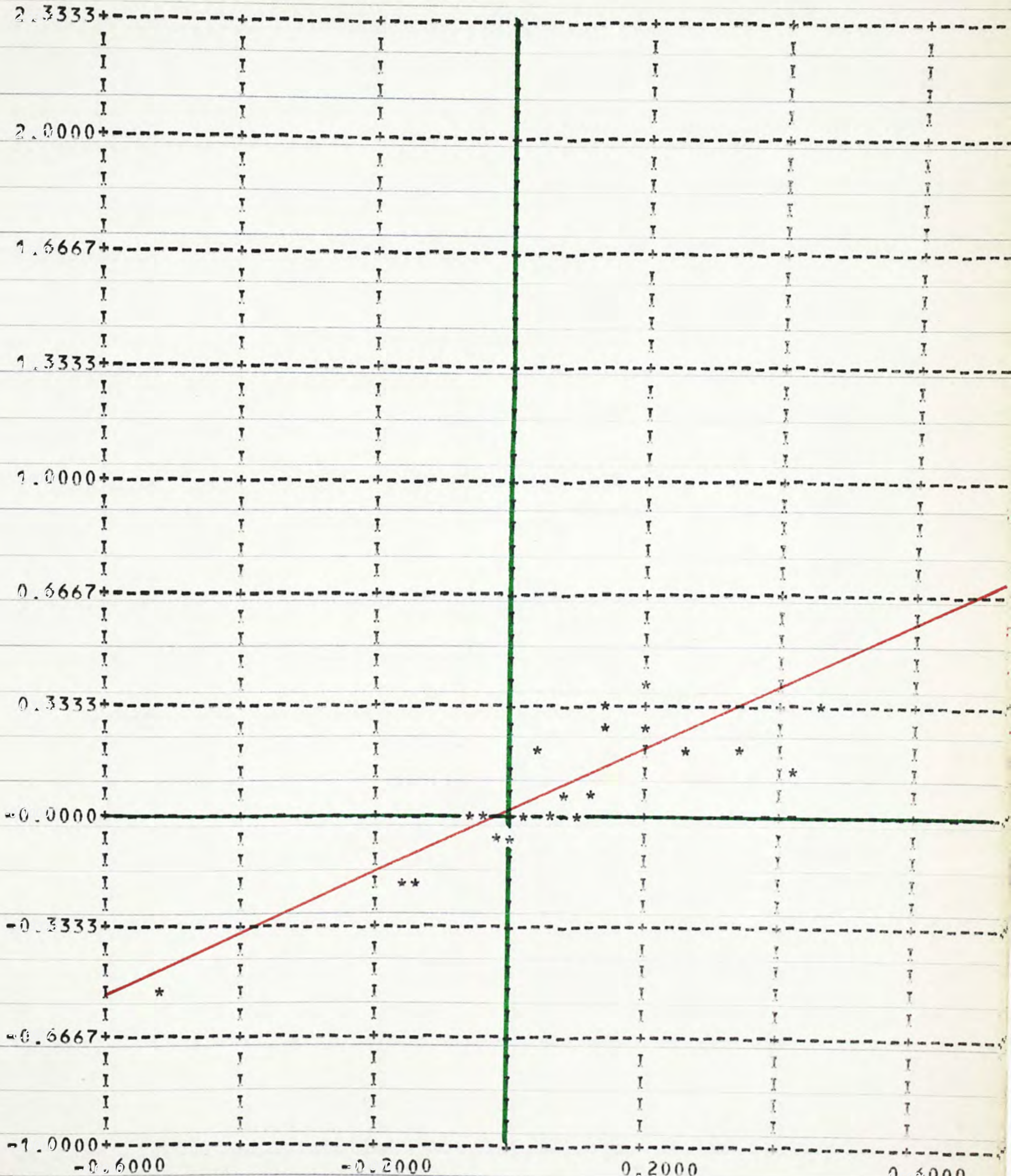
THE HONGKONG AND KOWLOON WHARF AND GODOWN COMPANY LIMITED

FIGURE 9



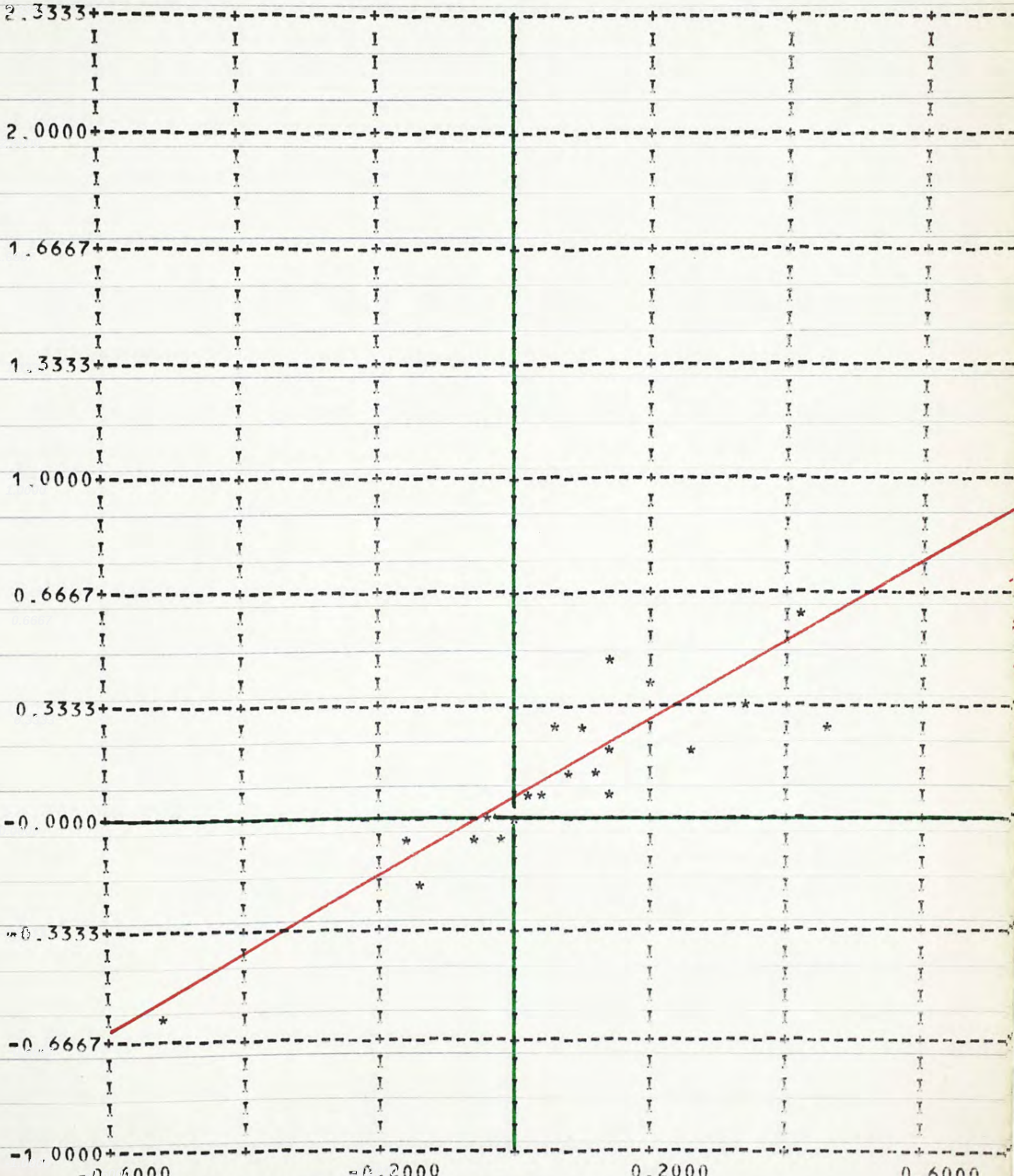
THE HONGKONG LAND COMPANY LIMITED

FIGURE 10



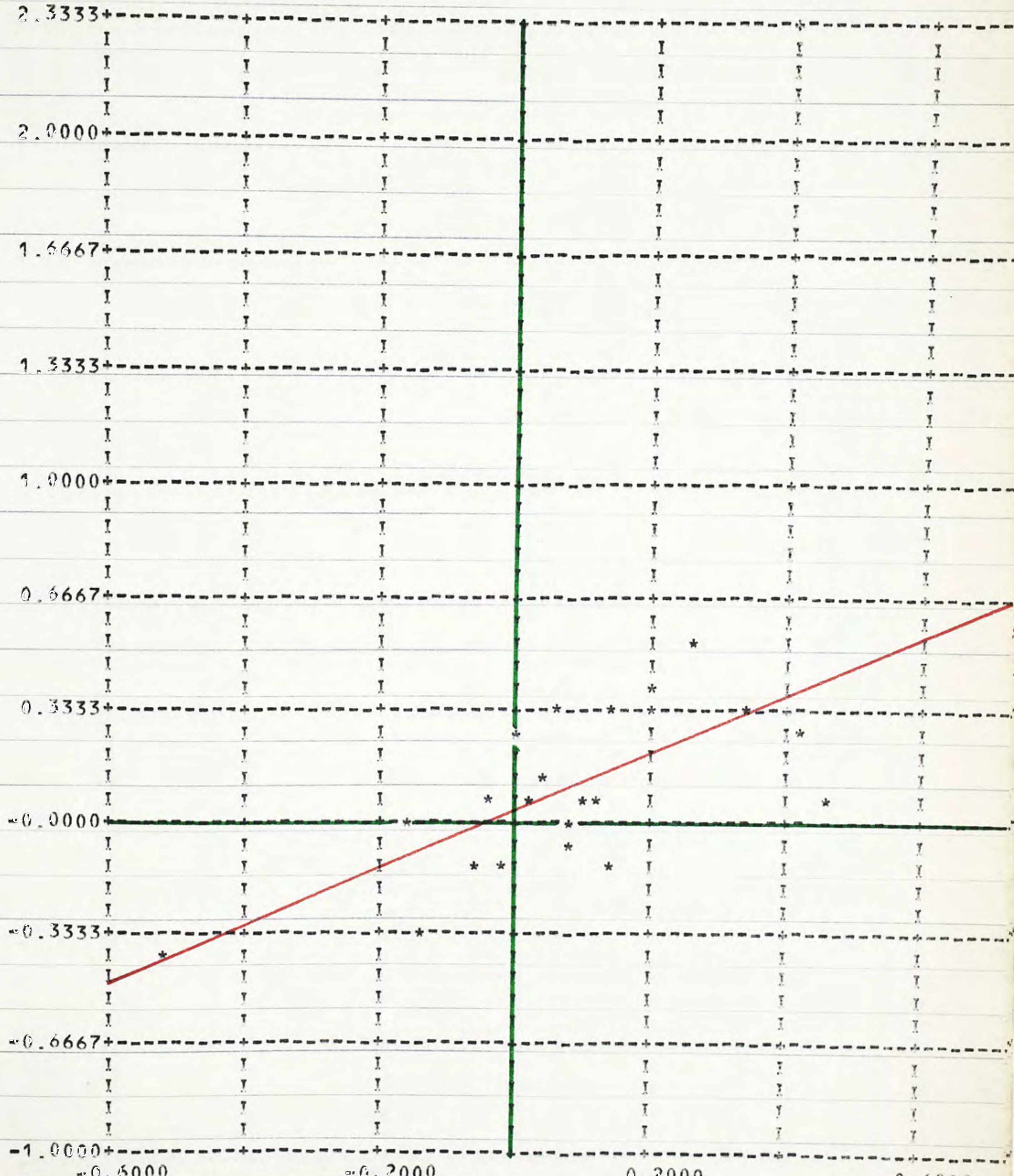
HONGKONG REALTY AND TRUST COMPANY LIMITED

FIGURE 11



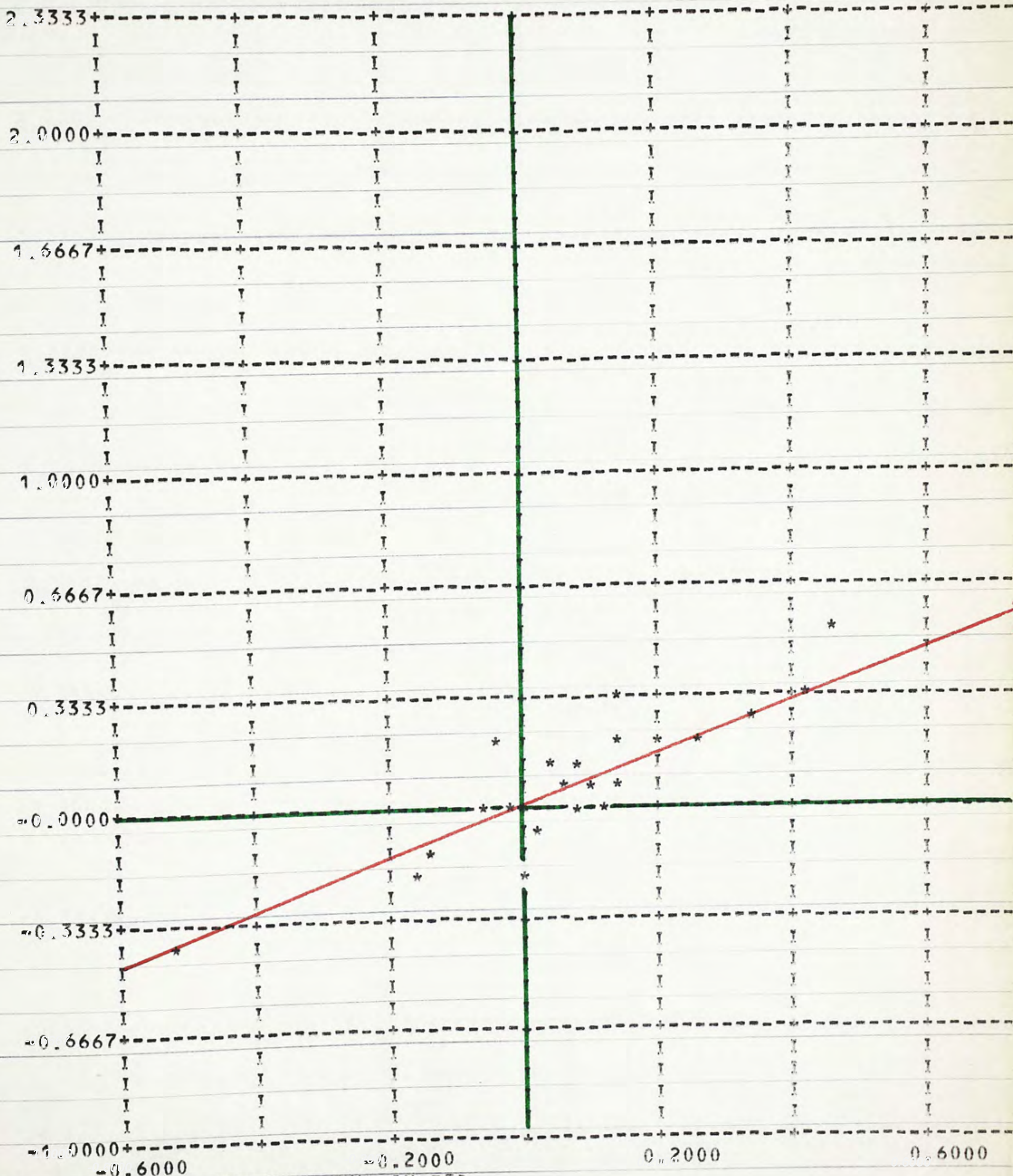
THE HONGKONG AND SHANGHAI HOTELS LIMITED

FIGURE 12



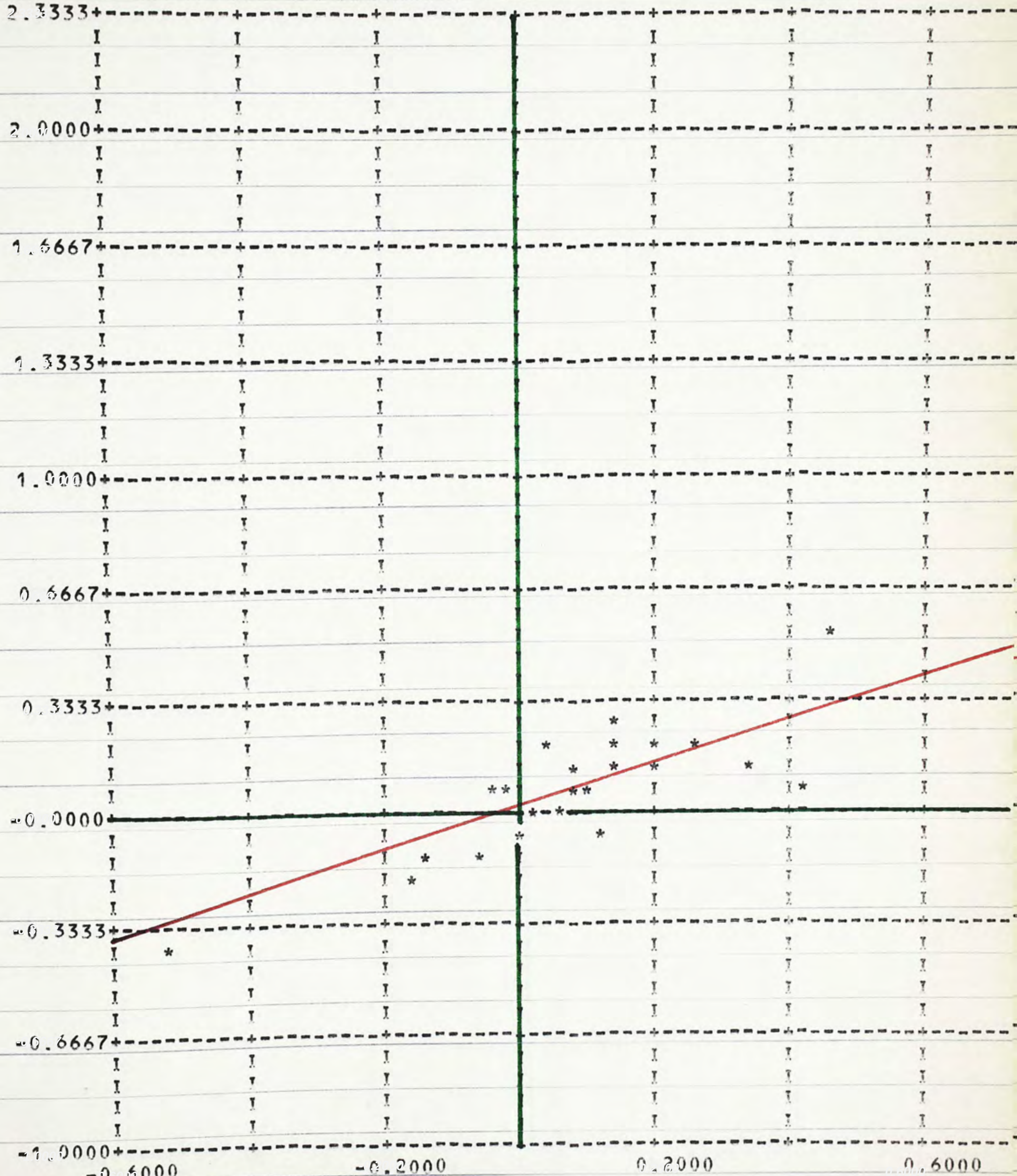
CITY HOTELS LIMITED

FIGURE 13



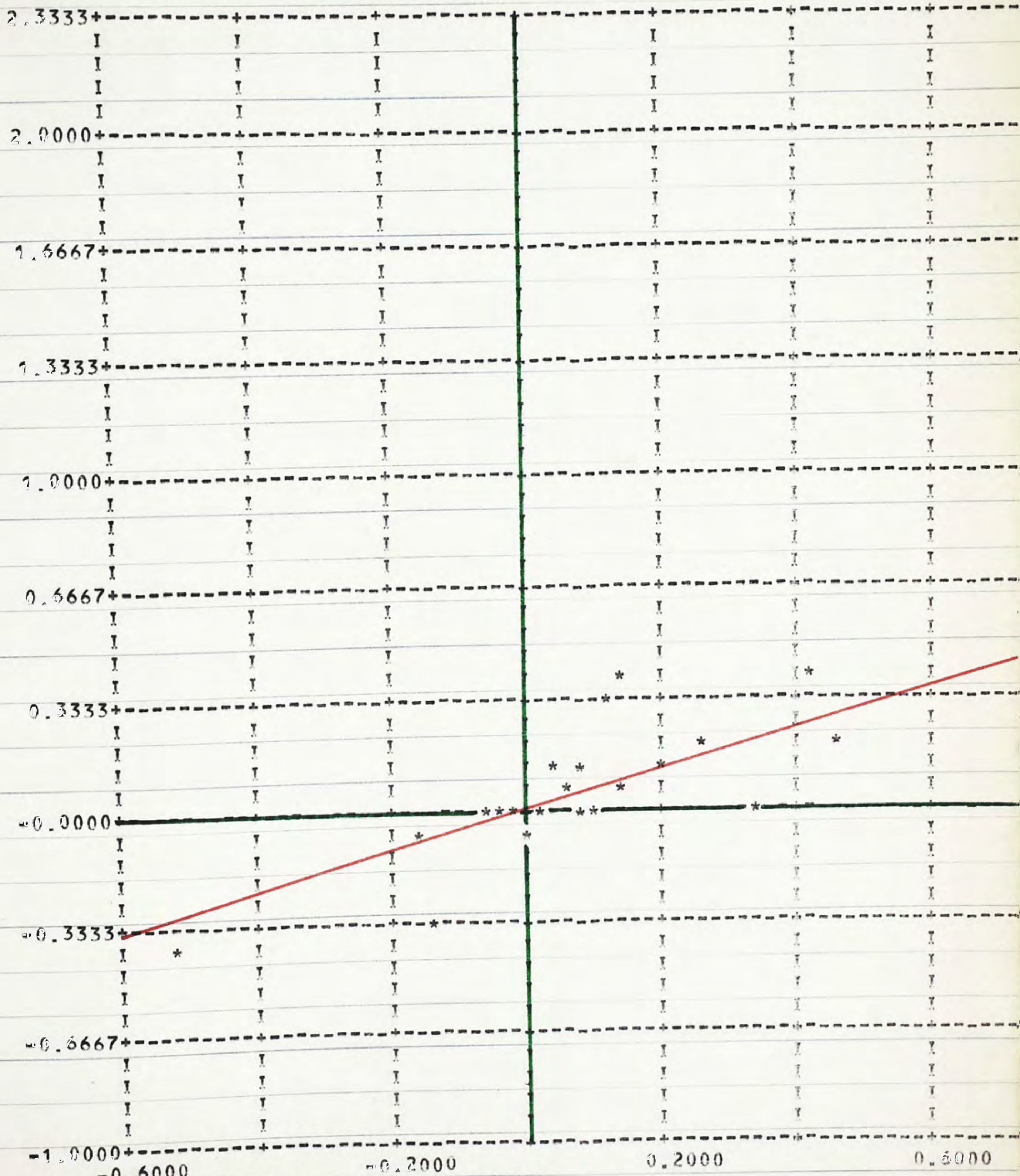
CHINA LIGHT AND POWER COMPANY LIMITED

FIGURE 14



HONG KONG TELEPHONE COMPANY LIMITED

FIGURE 15



THE HONG KONG AND CHINA GAS COMPANY LIMITED

FIGURE 16

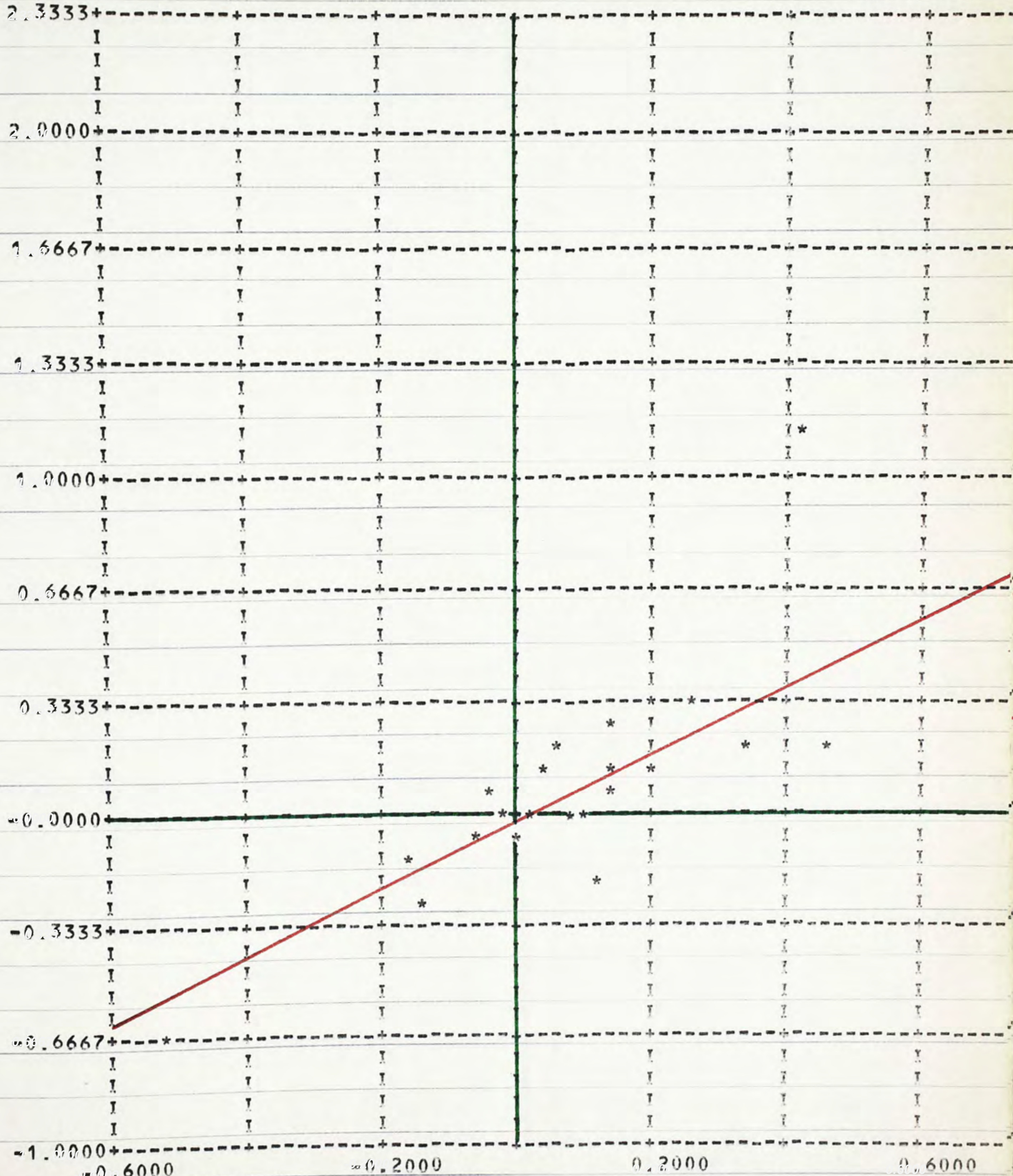

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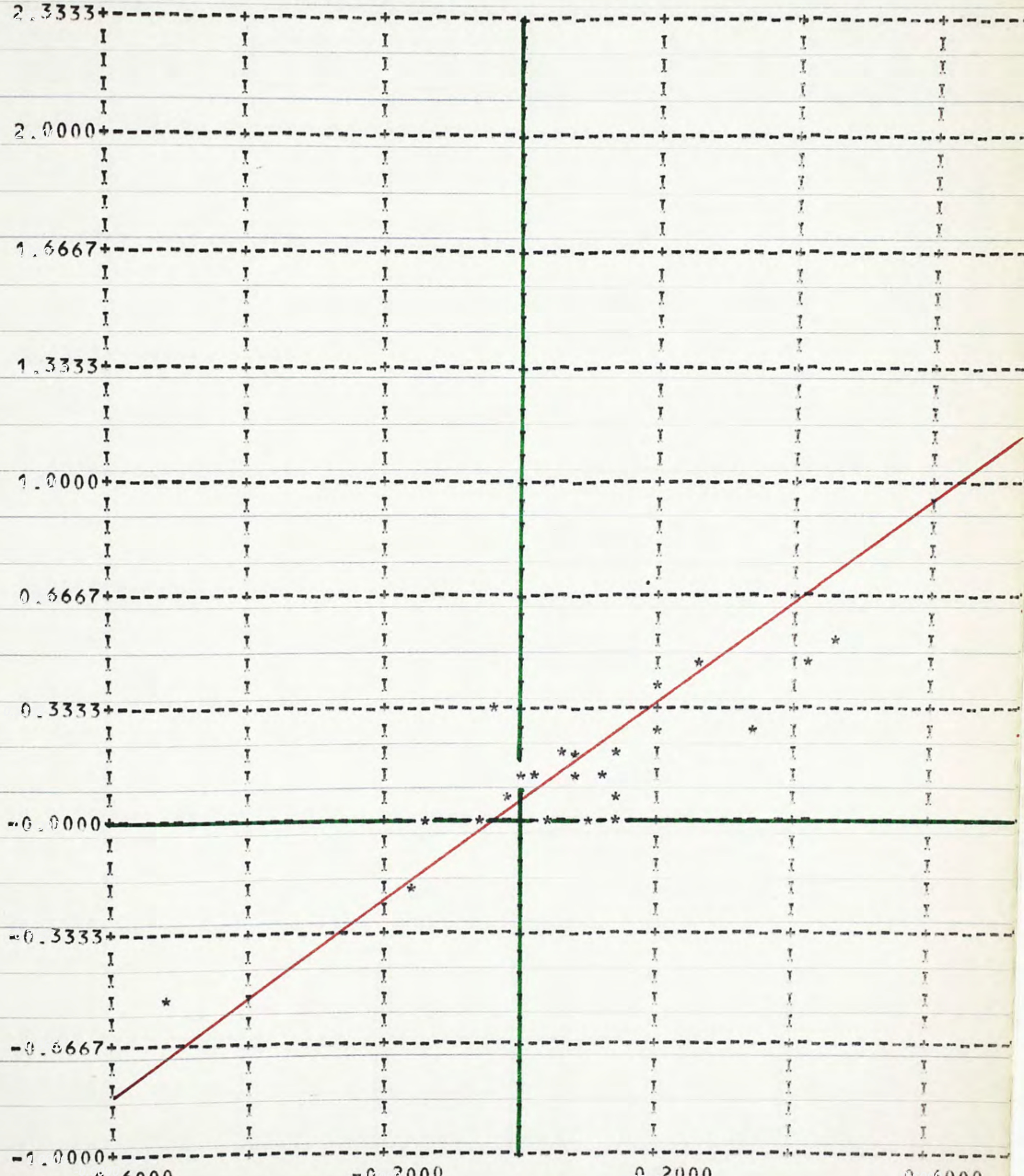
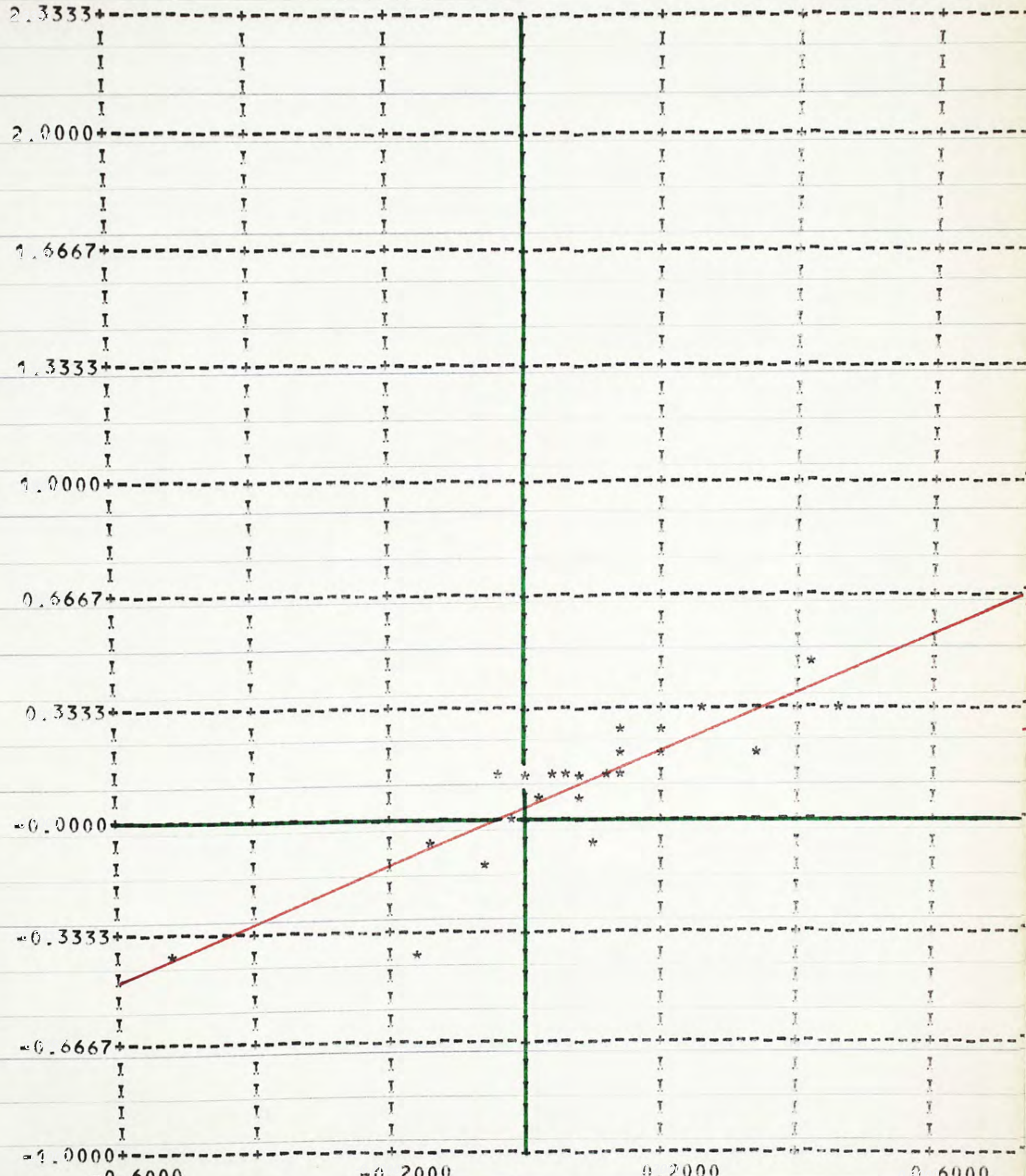
FIGURE 17



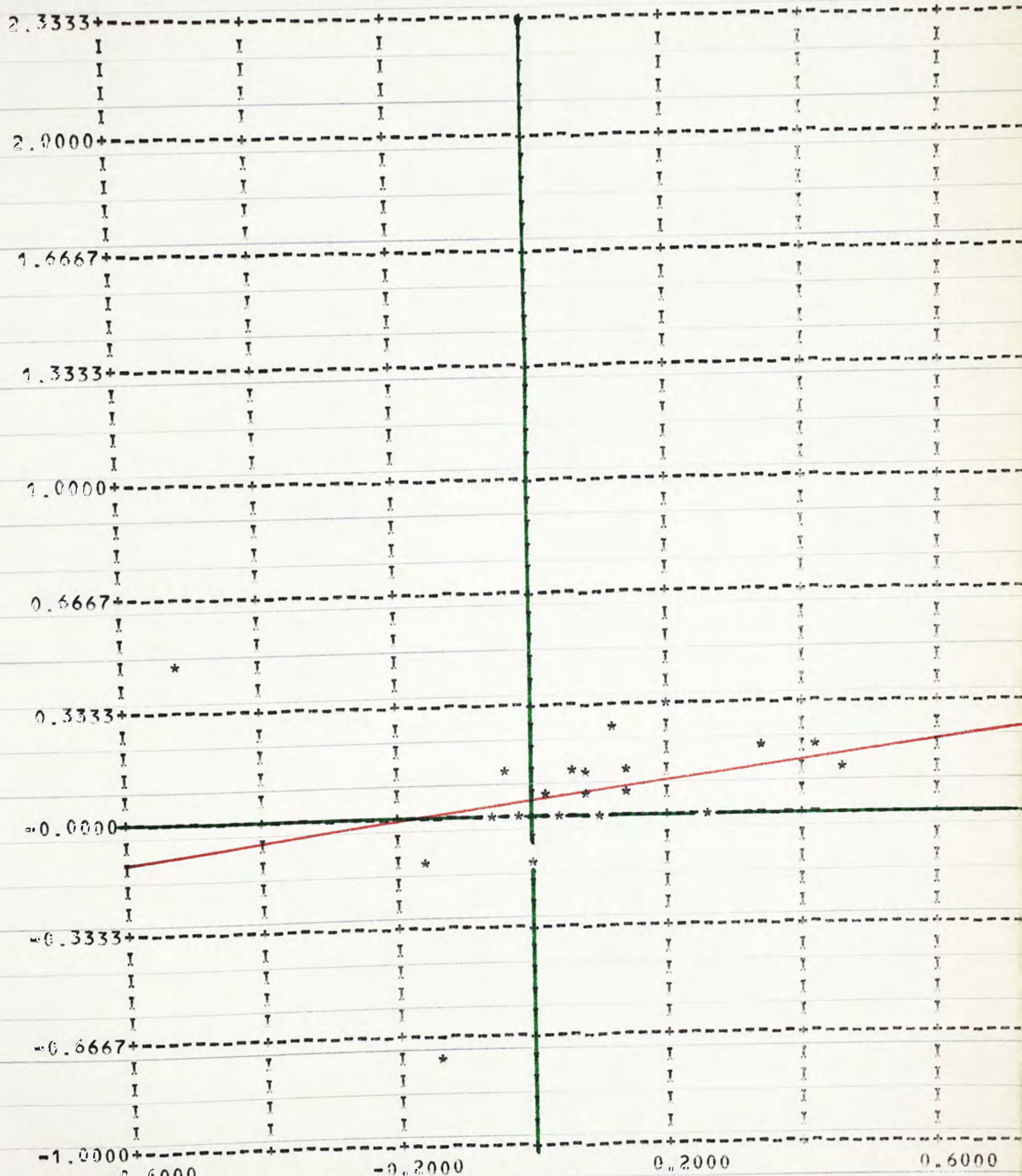
JARDINE, MATHESON AND COMPANY LIMITED

FIGURE 18



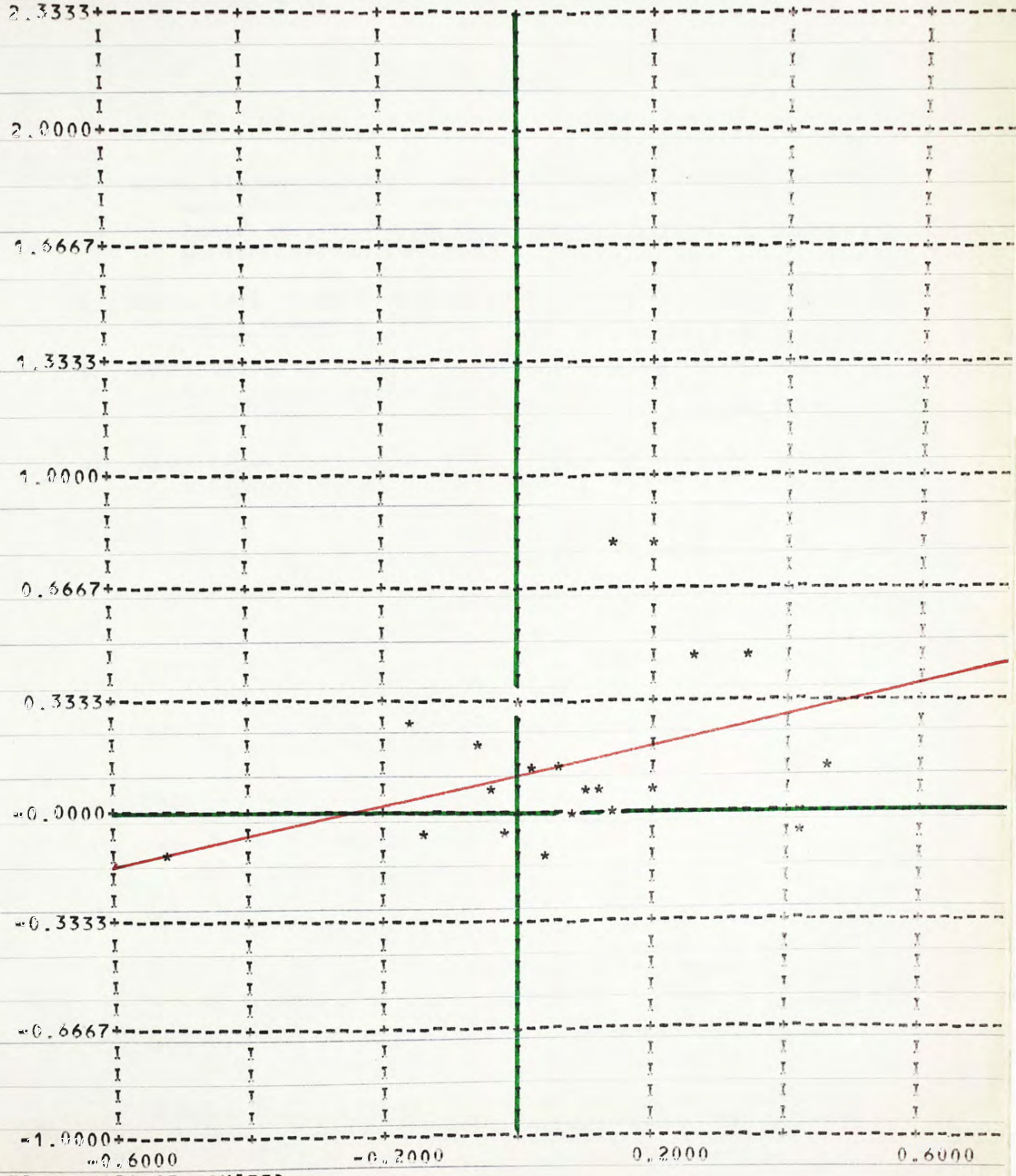
WHEELOCK MARDEN AND COMPANY LIMITED

FIGURE 19



A. S. WATSON AND COMPANY LIMITED

FIGURE 20



TEXTILE ALLIANCE LIMITED

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香港選樣證券之組合投資分析

(一) 引言

此篇論文是研究最新證券組合技術，稱為證券組合投資理論，並將之應用到本地的證券市場。此理論最主要目的，在將投資風險數量化，計算出一個最好的證券組合，以供投資者使用。

研究方法，是利用電腦以及二次程序編制技術(Quadratic Programming Technique)來分析本地證券市場的一些選樣證券；並利用威廉．沙氏的單一指數模式(William Sharpe's Single Index Model)進行分析。

(二)證券組合投資理論的歷史發展

組合投資分析在近年來業已演變至白熱化及嶄新階段。這是由於高利率的壓力和測度技術的進步所致。以往歷史背境反映出投資分析家缺乏表達風險數量的能力及其與投資利潤的關係。又因風險數量化因素之缺乏，以致混淆組合投資行為測度和投資決策過程。

一九五二年，夏利．馬哥維士(Harry Markowitz)首先提出一個解決風險數量化的簡單而有力的方法。自後，在財務方面，尤其是在投資方面，引起革命性的變化。其中表現出色且有深度的，有威廉．沙氏。他的新思想——現代證

券組合理論（Modern Portfolio Theory）或稱資本資產價格理論（Capital Asset Pricing Theory）——是從馬哥維士的理性投資行為命題脫胎而出。雖然，這一理論和技術的演進過程，或在投資界的接受速度方面都嫌緩慢，但在美國的證券市場上，現代證券組合理論已被開始採用。

(三) 組合投資

現代證券組合投資包括四個階段，即：證券分析（Security Analysis），證券組合投資分析（Portfolio Analysis），證券組合投資選擇（Portfolio Selection），和證券組合投資修正（Portfolio Revision）。

第一階段的證券分析，是將市場上所有證券加以分類，並預測證券的未來前途。包括各種證券利潤率、風險、及其相互間關係，以備第二階段應用。

第二階段的證券組合投資分析，是預測各種可能的證券組合。此一分析決定證券組合將來的利潤報酬和風險的可能性，即馬哥維士的分散法(Diversification)。在此項方法下，證券組合投資希望避免風險，並在風險中求取最大的利潤。此一最有效率的証券組合投資集(Set of efficient Portfolio)為第三階段提供了必要的資料。

第三階段是證券組合投資選擇，投資者可以選出他的

最佳證券組合，以滿足其投資目的。

第四階段則是證券組合投資修正。在選擇投資之後，由於證券市場的變動，投資分析家須不時注意市場的動態，並根據市場所得資料作適當的組合投資修正。

(四)香港證券市場

在香港證券市場，投資出路不多，機構投資者在組合投資方面，只有向普通股股票(Common Stock)發展；在投資方面，他們大多沒有完善的選擇和評價制度。投資者對投資風險多不關心，又未將風險數量化，所以在香港投資界，差不多完全沒有風險數量化和β系數(Beta Coefficient)的存

在。

在香港，選擇證券組合投資差不多是隨意而為。普通的方法是隨投資者的心意而組合，他們大都不知道為什麼選擇這個投資組合，又不知道另外一個組合可否帶來更大的利潤，或可能減低投資風險。

(五)研究範圍與方法

在範圍方面，由於理論太廣，作者只能對證券組合投資過程(即第二階段)作深入的研究，其餘第一階段的證券分析及第三階段的証券組合投資選擇則只略作研究，至第四階段(即證券組合投資修正)，涉及較多理論背境，故作者未

加研究。在選樣方面，作者只選了二十種具有六年歷史的普通股股票作為分析對象，雖然選樣受到限制，但作者認為已足夠完成研究目的。

在研究方法方面，首先在圖書館研究理論上的背境和知識，第二步是設計程序(Computer Programming)並利用電腦來解釋二次程序編制的問題。之後，開始收集所需資料，大部份都是從香港證券交易所取得。另一方面，作者亦曾接觸投資界的權威專家，以求取得香港市場的第一手資料。論文最主要而又最有趣味的部份，是分析資料和解釋結果。最後，作者檢討他在本文中所用的技術，所受的限制，

及若干應用上的問題，並總括研究結果。